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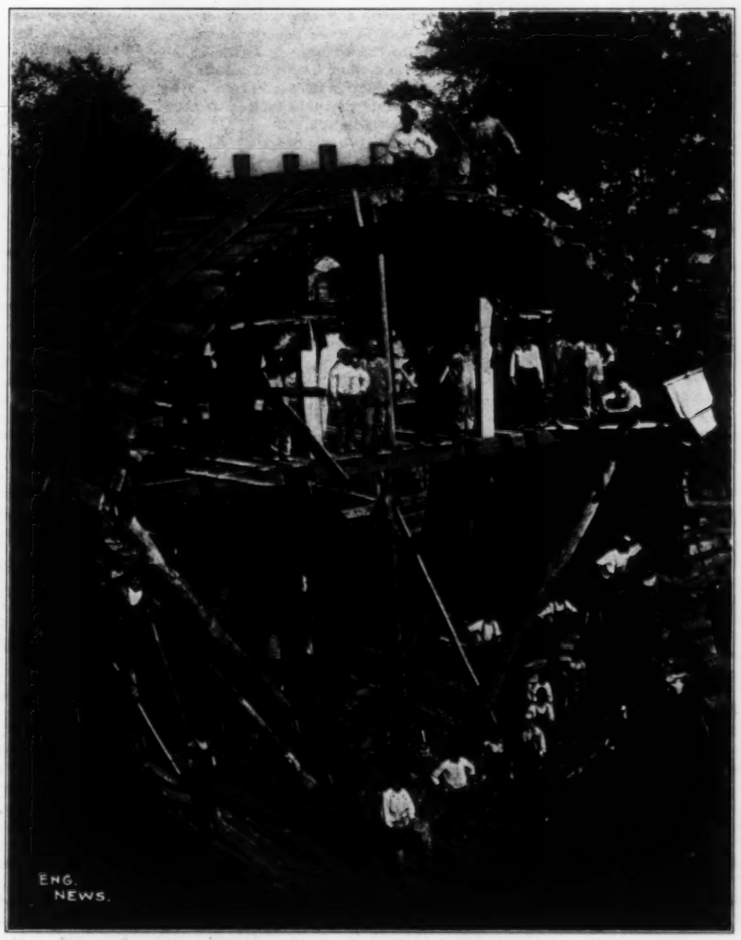
A CIRCULAR WOODEN CAISSON FOR A PIVOT PIER.

The accompanying photograph shows a very large circular caisson recently built as a mold for the concrete pivot pier of a drawbridge at Passaic, N. J. The contractors for the work were the F. R. Long Co., of Hackensack, and at our request Mr. Long has furnished us the following description of the building and launching of the caisson and the construction of the pier inside it:

We built the caisson on the ground, constructing first two large rings 34 ft. inside diameter. These were built up from 10 x 12-in. yellow pine timbers bolted together in segments. The rings were then set upon edge and braced together. The sheathing (6-in. tongued and grooved yellow pine) was then spiked inside the rings in a manner similar to setting up a barrel, and when the caisson was completed it was rolled into the river at high tide. In order to have the cylinder assume a vertical position when it landed in the river we drove a few piles and laid two skids, one arranged to tip after the cylinder had rolled about half the length. This worked well and the cylinder landed in the position we wished to use it. We then took our derrick scow and pile driver and lifted the cylinder over the piles which had been cut off about 3 ft. from the bottom, and lowered the cylinder in position around the piles.

The bottom of the river at this place was sand and by manipulating the cylinder, and some excavating by a diver, we settled the cylinder into the sand about 18 ins. Concrete was then lowered into the cylinder with a dump bottom bucket until the cylinder had been filled to a depth of about 8 ft. After the concrete had set 48 hours the cylinder was pumped out and held the water very nicely, and the concreting was continued comparatively dry to a point about 5 ft. below the low-water line. The pier was then completed with cut-stone work. A large iron band was dropped down outside of the cylinder to a point level with the top of the concrete. The cylinder was then cut off with a pile saw 6 ins. above the concrete, and all timber above that was removed. The water where the pier was built is about 20 ft. deep at low tide and there is 5½ ft. of tide in the river. The work is substantial and seems entirely satisfactory.



A HUGE CIRCULAR CAISSON FOR A CONCRETE PIER AT PASSAIC, N. J.

THE CONSTRUCTION OF THE MANHATTAN Bridge across the East River at New York City is one step nearer as the result of a Supreme Court decision on June 1, dismissing the taxpayer's injunction obtained some time ago by Mr. Edward E. Pabst on the ground that the proposed contract was a waste of public funds. Mr. Pabst announces his intention of appealing from the decision, so that the matter of letting contracts will be held up indefinitely.

AN OFFICIAL REPORT ON HEAT CONDITIONS IN THE NEW YORK SUBWAY BY CHIEF ENGINEER GEO. S. RICE.

As our readers will recall, the high temperatures in the New York subway which were experienced in the summer of 1905 were first shown in the columns of this journal to be due to the great amount of electric energy which is dissipated in the subway in the form of heat.

We published a report on this subject by Dr. Geo. A. Soper in our issue of March 8, and present below a report by Chief Engineer Rice, dated May 16, giving a full statement of heat conditions in the subway and possible remedies therefor:

The Engineering Staff of the Rapid Transit Commission has made very careful studies with reference to providing means for improving the condition in the subway during summer. These investigations were begun in 1903, before the construction work was completed, and have been continued until the present time.

These investigations were in charge of Mr. D. L. Turner, a member of my Executive Staff; Mr. Turner was assisted in this work by Mr. L. C. Brink, Mr. J. T. Kane and Mr. G. F. Simpson, assistant engineers. In the main the scope of the investigations has had reference to the heat conditions in the subway, with a view to determining the cause of the conditions, the modifying factors and the possible remedies.

GENERAL CONCLUSIONS.

From a study of all the investigations which have been made, we arrive at the following conclusions:

1. Before operation, the subway in winter was warmer and in summer cooler than the street. In the spring and fall the inside and outside temperatures were about the same.

2. All of the electrical energy consumed in operating trains (about 83% of that generated at the central power house), is utilized in overcoming friction and is thereby transformed into heat in the subway. In addition to this heat a relatively small amount of heat is given off by passengers using the subway. The total amount of heat that may be liberated when the ultimate train schedule is in operation may be nearly 100% greater than the amount liberated during the operating conditions of the past summer.

3. The greater part of all this heat is dissipated through the floor, sidewalls and roof of the subway structure into the adjacent ground. A relatively small amount is carried out of the openings of the subway by the exhaling and inhaling action of the trains. The effect of the remaining heat is to increase the temperature in the subway after operation.

4. The air in the subway between stations is not renewed frequently by the inhaling and exhaling action of the trains, while at stations the renewal is more frequent. The renewal action is almost entirely local, its effect being mainly felt in the immediate vicinity of the openings, whether at stations or interior points.

5. At any interior section of the subway or at a station the temperature varies at different points at the same time. These local variations in the temperature are more marked at stations than at interior points.

6. There are daily variations in the subway temperature—the variation at stations is about twice as large as that at interior points.

7. There are seasonal changes in the subway temperatures. The temperatures at interior points are about 12, 20 and 15 degrees in winter, spring and summer, respectively, higher than the temperature before operation; and 25 and 6 degrees, in winter and summer, higher than the temperature of the outside air. At stations, about 5, 15 and 12 degrees higher than before operation, and 18 and 3 degrees higher than the outside air, during corresponding seasons.

8. The sanitary condition of the subway air is good, and the humidity conditions are satisfactory; on the other hand, there is a considerable quantity of fine iron

dust liberated by the wear upon the rolling stock and rails.

9. Such renewal of air as does take place, is frequent enough for the ordinary purposes of ventilation, as ventilation is commonly understood, but is not sufficient to remove any large amount of the fine particles of iron dust due to an excessive wear of rolling stock and rails. Also the renewals are not frequent enough, nor do their maximum effect occur at the proper periods, to materially reduce the heat in the subway. Therefore, the air must be removed more frequently than at present throughout the whole subway.

10. The problem of improving conditions in the subway is mainly one of heat disposal; in consequence of this, resort must be made to some method of cooling it, to be determined upon by actual experiment.

RECOMMENDATIONS.

In order to improve the conditions in the subway, throughout the year, and more particularly during the summer, it is recommended:

1. That the air be completely removed from the subway once every half hour through chambers located midway between stations, thereby inducing an inflow of fresh air at the stations.

2. That the removal of the air be accomplished by the combined action of automatic louvres and motor-driven exhaust fans; the louvres to be relied upon during the daytime and the fans at night.

3. That additional openings be provided at the stations to facilitate the inflow of fresh air.

4. That extensive experiments be conducted during the summer in order to determine the best method for cooling the air; since recourse must eventually be had to cooling, in addition to air renewals.

Finally, to carry out the above recommendations the following specific works are proposed:

From Brooklyn Bridge to the Columbus Circle station it is proposed to provide 14 outlet chambers. It is recommended that these chambers be constructed as louvre and fan chambers combined. It is understood that the louvres are to be continuously operated, but that the fans are only to be used for 12 hours (at night) out of the 24 hours, during the three months in summer, when the heat condition is excessive; and during any emergency period.

Further, it is proposed that the chambers be made slightly larger than would be required for fans and louvres combined, in order that an emergency exit may be provided through these chambers to the street at points in the subway midway between stations.

The louvres and fans are to be designed to effect a complete renewal of the air throughout all parts of the subway once in thirty minutes. Except in three instances, the chambers are to be constructed under the sidewalks adjacent to the subway structure. The air from the chambers is to discharge into the street through gratings in the sidewalk surface. In the three excepted instances noted the discharge is to be through gratings, but these gratings are to be located in the parkway areas.

If it is found necessary, it is proposed that the fans be provided with cycloidal discharge tubes in order that the velocity of the discharge through the gratings may be reduced to five miles per hour, thereby overcoming the objectionable features of such method of discharge.

This plan provides for a measure of renewal throughout the year by means of the louvres; it insures a maximum renewal during the night hours during midsummer by the fans, thereby attaining the maximum cooling effect possible due to renewal; it provides emergency exits throughout the subway between stations, and finally makes provision for a positive removal of smoke from the subway in case of fire.

From Columbus Circle to 96th St. the subway has been found to be invariably cooler than between Brooklyn Bridge and Columbus Circle. This is due to the fact that in the former section ventilating openings are provided over the subway between stations. To accomplish the same measure of improvement in this portion of the subway as it has been planned to attain south of Columbus Circle, it is proposed to install louvres in all the ventilating openings north of Columbus Circle to 96th St., and as an adjunct to louvres, and for emergency purposes as above, fan houses are to be erected in the Parkway over the central openings between each two stations, and fans installed.

To facilitate the action of the fans and louvres, more openings should be provided at the stations for the inlet of fresh air. To accomplish this, it is proposed to cut out 6,200 sq. ft. of vault light work at the several stations. In these vault light openings gratings are to be provided. Where the gratings occur over station platforms, copper pans are to be placed under them to provide for drainage.

When the above plans are carried out the condition in the subway will be improved to a marked degree.

INVESTIGATIONS IN DETAIL.

1. Temperatures Before Operation.—Observations made by others have shown that the downward propagation of the summer warmth from the surface into the ground is so slow that it is not felt at a depth of 25 ft. until the following winter. At that depth the annual range of temperature is reduced to less than one-twentieth of its value at the surface. Ordinary daily changes of temperature are not apparent over a few feet in depth.

Before operation, when no heat was being liberated in the subway due to operation of the trains, the subway in winter was about 15 degrees warmer and in summer about as much cooler than the street.

The average subway temperatures before operation for each month of the year were approximately as follows.

January	41°F.	July	68°F.
February	41°F.	August	69°F.
March	41°F.	September	68°F.
April	46°F.	October	63°F.
May	56°F.	November	59°F.
June	64°F.	December	50°F.

The range of temperature in the ground around the subway should not change materially from year to year. What this effect may be has not yet been determined. It is possible, but hardly probable, that there may be a gradual heating up of ground due to an accumulation of heat from year to year. Observations are now being made with a view to determining this effect. Assuming no material change, the above monthly temperatures will represent the approximate net temperatures of the ground surrounding the subway.

2. Heat from Operation.—Only about 83% of the total electrical energy generated at the central power house is used for operating purposes in the subway. The remaining 17% is consumed in transmission, and in the converters and transformers at the sub-stations. All of the electrical energy consumed in operating trains is utilized in overcoming friction, and is thereby transformed into heat.

The amount of heat being liberated by the rolling stock in any interval of time is dependent upon the train schedule being operated and the number of cars making up the trains. Both of these factors are subject to large variations, due to the changes in traffic conditions throughout the day and from month to month.

There is also a certain quantity of heat given off by the passengers. This probably amounts to less than 2% of that liberated by the rolling stock.

The approximate amount of heat liberated from all sources, from the Bridge to 96th St. station is:

	Minimum. 12 to 5 a.m.	Maximum. 8 to 9 a.m. 5 to 6 p.m.	Average.
(1) B. T. U. per hour for the July, 1905, operating conditions	4,689,300	42,400,000	25,285,000
(2) B. T. U. per hour for the assumed maximum summer period	8,441,000	76,320,000	45,000,000

Approximately the amounts of heat liberated from all sources, at express and local stations, and in the subway between stations, are 8, 16 and 76 per cent respectively, of the above totals. In detail the amounts are as follows in B. T. Us. per hour:

	Minimum.	Maximum.	Average.
(3) At each express station (there are 5 stations) July, 1905, operation	44,600	790,600	396,000
Maximum summer period	80,300	1,423,100	713,000
(4) At each local station (there are 16 stations) July operation	44,600	321,500	197,000
Maximum summer period.	80,300	578,700	353,000
(5) The subway between two stations at the average distance apart (there are 2 distances) July operation	178,700	1,585,800	914,600
Maximum summer period.	321,700	2,854,400	1,646,000

3. Loss of Heat from the Subway.—It would seem that most of the heat given off from the trains reaches the floor, sidewalls and roof by radiation. At the same time, because the inside temperature is always higher, the whole structure is conducting more or less heat into the ground around it. The rate of conduction, however, is variable, depending upon the heat head, decreasing from winter to summer and increasing from summer to winter again. Under a condition of constant inside and outside temperatures the floor, sidewalls and roof would probably permit the dissipation of heat in a varying degree. The total amount carried away is very much less than it would be, on account of the waterproofing which envelops and insulates the whole structure. While concrete itself is an exceedingly poor conductor of heat, and therefore a good insulator, the waterproofing envelope probably reduces the conduction through the walls of the structure itself by about one-third of what it would be if there were no waterproofing. This factor affects all portions of the structure alike. On most of the floor there is 10 ins. of broken stone ballast with the interstices between the stones filled with air; this additionally insulates the floor. On the sidewalls the cable ducts, and sometimes the hollow tile wall constructed outside of, and to protect the waterproofing, also provide air insulation. On the roof there is only the waterproofing. The total conduction through the roof is greatest. Of the floor and sidewalls, the insulation of the latter is probably more effective.

But while the relative conductivities of the roof, sidewalls and floor are different and thereby permit the conduction of heat through them in varying degree, the [illegible] loss from the subway is affected by another consid[illegible]. The amount dissipated is dependent as much up[illegible] depth of the structure below the surface as up[illegible] conductivity of the structure itself.

To show this, it has been calculated that a[illegible]mately .21 B. T. U. per sq. ft. per hour is con[illegible] away through the concrete of the roof, then throu[illegible] earth cover and thence into the air, for 1° differ[illegible] temperature (when the earth cover is 6 ft. de[illegible] there were no cover the same temperature di[illegible] would give a conduction of .34 B. T. U. per sq. [illegible] hour—an increase of 33%.

The manner in which the outward flow of heat [illegible] place is as follows: At the beginning, when the [illegible] of the roof first began to get warm, heat was con[illegible] into the concrete and steel of roof, gradually w[illegible] them up to a constant temperature gradient th[illegible] the mass—the inside enough warmer than the ou[illegible] to cause a continuous flow of heat—then the water[illegible] was warmed up in the same manner until its temp[illegible] gradient became constant, with another slight di[illegible] between the inside and outside temperatures [illegible] the layers; similarly the heat passed through the [illegible] above the waterproofing, thence through the gro[illegible] to the surface, and finally by radiation into the air. The gradient once established heat flowed continuou[illegible] from inside to outside, in amount dependent upon the difference in temperatures or heat head.

Again, the approximate drop in temperature through the various layers from inside to outside, for 10° difference, has been calculated to be as follows: Inside concrete 2.1° waterproofing 1.9°, protecting concrete 1.0°, 6 ft. earth cover 3.9°, and loss by radiation from the surface 1.1°; total, 10.0°. It must be remembered that the above values can only be approximate, but they are interesting as an indication of the relative conditions. They show, too, that the greater the depth of the subway below the surface the less the amount of heat dissipated, and, therefore, the warmer the subway. But this is the opposite of what our observations show at great depths, namely, that it is coolest between the 33d St. and Grand Central stations, the deepest portions of the subway between the Bridge and 96th St. The reason that the above conclusions do not apply in the latter case is because of the water in the ground.

We know that there is a large amount of water stored in the ground, even up to within 5 or 6 ft. of the surface. The water thus stored varies all the way from 4% of the dry weight for coarse mixed sands, increasing in finer sands, sand and clay, clay, and up to 40% in loam. These amounts are about 75% of the quantities which the same soils would contain if they were below the plane of saturation—or ground water level. There is, then, a surprisingly large amount of water in ground above the ground water level—up nearly to the average level of the subway roof. All ground water is constantly in motion; when not flowing freely it is subjected to other gravitational movements, or movements due to capillary and heat actions. We know, too, that the specific heat of water is relatively higher than any other substance; it therefore warms up slowly. For these reasons, then, water surrounding the subway will be warmed very slowly by the heat it absorbs, and will continually carry heat away with it from the structure, and so constantly maintain a relatively greater difference between the inside and outside temperature, and thereby produce a relatively cooler condition in the subway. The conclusions stated at the outset, then, only apply in the case of dry ground, or practically that portion of the ground forming the cover of the subway at the normal depth.

The floor and sidewalls could be studied in the same manner as the roof, but it is unnecessary. The same phenomena concerning heat conduction through the structure occur, only modified somewhat. The amount of heat passing through the structure is less because of better insulation. The total amount dissipated from the subway may be greater or less than at the roof—depending upon the season. As a matter of fact the flow may be reversed in winter, that is, heat may flow into the subway through the floor and sidewalls from the ground.

Of course, all of the above conditions are modified more or less by the local ground structures, such as pipes, conduits, etc., in the street, giving off heat, and the proximity of heated building vaults.

It has been estimated that the loss of heat through the structure into the ground amounts for a 100-ft. section of two track subways to approximately 4,250 B. T. U. per hour per 1° F. difference between the inside temperature and net temperature of the ground surrounding the subway; or from the Bridge to 96th St., 1,402,250 B. T. U. per hour per 1° difference in temperature. The average rates of loss through the roof, sidewalls and floor have been found to be approximately 50, 10 and 30% respectively, of the above amounts.

The entire section of the subway under consideration contains about 26,800,000 cu. ft. of air. For every degree in temperature which the above volume of air is cooled, 511,000 B. T. U. are removed, from which the heat removed by air renewals can be determined.

Based upon the approximate passenger minutes and

the amount of CO_2 found in the subway by Dr. Soper, it was estimated that the air was renewed about once in every 3 to 5 hours during July, 1905.

The heat units liberated in the subway, the approximate quantity dissipated through the structure, the estimated loss due to renewals, and the temperature of the surrounding ground, have now been determined. In terms of all these quantities an expression has been evolved from which, knowing the outside temperature, the approximate inside temperature can be calculated. The equation is:

$$(St) = 1.957 \frac{H + Ot + 3n\ Gt}{3n + 1} = \text{the approximate average}$$

temperature in the subway between Brooklyn Bridge and 96th St. stations. (H) equals the total B. T. U. per hour, expressed in millions, liberated from all sources for the entire section of the subway. (n) is the time in hours during which a complete renewal of air takes place. (t) is the average daily (24 hrs.) temperature of the outside air in degrees Fahr. (Gt) is the net ground temperature in degrees Fahr.

To test the equation, the subway temperatures were calculated during different months, and the results plotted on a chart for comparison with the actual averages as observed. No material difference occurs. In employing the formula, the result is obtained tentatively. First, an approximate temperature is computed without considering the factor (n); then assuming that (n) varies inversely as the square root of the difference between the inside and outside temperatures, its value is obtained (assuming (n) equals 3.5 for a 6° difference). Entering the equation again with the computed value for (n), we get a final and more nearly approximate quantity for (St).

The limitations of this formula must be thoroughly understood. It does not apply for short sections of subway, such as between adjacent stations. The conditions modifying the temperature are so many and so indeterminate, it is only when considering large general averages that such an equation can be used. In such a case the uncertainties are more or less eliminated.

Under the operating conditions during July, with an average outside temperature (Ot) of 78°, and (Gt) equals 68°, the subway temperature (St) was calculated to be 84°—agreeing with that observed. Now, we concluded that approximately 45,000,000 B. T. U. per hour from all sources might be liberated in the subway during a maximum summer period. Entering the equation with this quantity and the same outside and ground temperatures as above, it has been calculated that the corresponding average subway temperature throughout the section from the Bridge to 96th St. should be about 95°; as a matter of fact it might be worse. During some days in July the average outside temperature (from U. S. Weather Bureau) was as high as 86°, as against the value used, 78.

There have been warmer summer seasons than 1905, so it may be assumed that the daily average in some seasons may be as high as 90°. Under such circumstances the inside average temperature would be about 98°. The seriousness of the subway heat problem at once becomes apparent.

4. Exhaling and Inhaling Action.—It has commonly been thought that the exhaling and inhaling action of the trains resulted in a considerable renewal of the air in all parts of the subway. This is not the fact—as already pointed out. There is some outflow at the openings induced by the pressure in the air produced by the trains as they approach the openings; this effect is local, however; it is not felt materially at the innermost points. A single train only occupies about 13½% of the total interior cross-section of the subway. What actually happens at interior points during the passage of a single train is this: The motion of the train produces a pressure in front of it and a corresponding vacuum behind it. The air in front thereupon flows immediately to the point of least pressure—to the rear—thus producing a velocity in the air on either side in the opposite direction to the moving train. During this action a small amount of air is carried forward. If there were no trains traveling in the opposite direction in the same subway, the net result would be the removal of the air from the interior in a series of spirals, each approaching nearer the point of outlet. Before the momentum of a spiral in one direction has ceased, however, a train passes in the opposite direction, thus almost entirely nullifying the effect of the first train.

5. Temperatures After Operation. Local Variations.—At any interior cross-section of the subway the temperatures of the air, roof, sidewalls and floor, are practically the same within the same hour, only differing by from a few tenths to a few degrees. At any one station at the same hour of the day during the summer we found the temperatures varying as much as 12° or 15° at different points on the same platform. Usually the warmest points are the ends of the platform; that is, farthest removed from the stairway openings. If the adjacent interiors are warmer than the station, then the hottest point is the end of the platform towards the approaching trains, where the effect of the warm air exhaled by the trains is mostly felt.

Differing local factors modify the above conditions somewhat, both at interior points and at stations, such as ground water, pipes, conduits, etc., heated building vaults; and depths of earth cover over the roof. The amount of vault light is important. Its effect is to intensify the heat condition at the stations during the hot sunny days in summer. The glasses act as lenses in heating up the air immediately under them. Since the lights are at the highest points in the ceilings, and are enclosed and supported by walls several feet high, pockets are here formed which contain a large quantity of hot air not easily removed by the ordinary exhaling action. Usually the coolest interior point was between 33d and Grand Central stations; and more often the hottest was between Bleecker and Astor Place stations; 91st St. was more often the coolest station and Brooklyn Bridge the hottest. Of the whole subway—stations and interiors—the interior between 33d and Grand Central stations was the coolest point, and Brooklyn Bridge station the warmest.

July and August are the critical months. The highest observed by the Interborough people during the two months was 98° F. at the Times Square station on July 17. The highest daytime average from the Interborough observations was 93° at the Bleecker St. station on July 18.

6. Temperatures After Operation. Daily Variations.—The daily variations in the subway temperatures are due to: (1) The variation in the heat liberated in the subway from hour to hour. (2) The daily changes in the outside temperatures, through air renewal. (3) The daily changes in outside temperatures, as affecting the "heat head," thereby causing a variation in the amount of heat conducted through the structure.

There is a daily range in the outside temperature in this locality (New York) amounting to as much as 30°, sometimes, even in summer. This affects the temperature at interior points and stations to a greater extent in winter than in summer, because of the greater differences between the inside and outside temperatures in the former case.

It appears that contrary to popular belief there is no rapid renewal of air at the innermost points of the subway, except where the openings between stations occur, and then it is purely local, only affecting the interior in the immediate proximity of the opening. These openings may, however, reduce the interior temperatures sufficiently to cause the subway to be cooler here than at the stations—for instance, north of Columbus Circle.

While the daily variation is probably largely caused by the response of the subway temperatures to the outside changes, it is not wholly due to this. The amount of heat liberated at a station during the day varies with the number of trains being operated. This causes the station to be warmer at the "rush hours" of traffic, and cooler during the middle of the night when the traffic is lightest.

7. Temperatures After Operation. Seasonal Variations.—The average interior temperatures after operation are seen to be about 12°, 20° and 15° in winter, spring and summer, higher than the temperatures before operation; and 25° and 6° in winter and summer, higher than the temperatures of the outside air, except in the few cases noted when the inside air was coolest. The average amount of heat liberated inside during the year varies some, being greater in winter than in summer. We have already observed that the warmth in the subway before operation was due entirely to the temperature of the ground around it—there was no other source of heat, or, as stated before, the subway temperatures then represented the net ground effect.

It may be assumed that the net ground effect is the same now as it was before. But there is a continuous supply of heat at the present time, independent of the ground conditions; the effect of this heat is to maintain the inside temperature at a practically constant difference throughout the year above the temperature gradient due to ground conditions. But the ground temperatures change with the seasons; the inside temperatures consequently must respond.

If the interchange of air between the interior of the subway and outside were material, the after-operation temperatures would correspond more nearly than they do to the outside temperatures.

The air interchange effect is more marked at stations than at interior points, for the reason that the openings are in close proximity. The gradual outflow of warm air at night is more beneficial to the interior, while the train exhaling and inhaling action is more effective in improving the condition at the stations. Obviously the effect in either case is more marked in winter than in summer due to greater relative differences in temperatures.

At the stations the hot air from the interior is intermittently puffed out by the trains. But almost immediately before it can mix with the cooler outside air, a portion of the air just discharged, with another portion of cooler air, is drawn back into the station. In consequence of this the resultant cooling effect is relatively small, and such effect is even localized at points in the station, as already pointed out. If at all times a constant amount of air could be drawn into the station independent of the train action, the conditions would be much improved.

The average *station* temperatures after operation are about 5°, 15° and 12°, in winter, spring and summer higher than the temperatures before operation; and 18° and 3°, in winter and summer, higher than the temperature of the outside air.

8. Other Conditions.—From Dr. Soper's investigations, it appears that the sanitary conditions of the subway air is as good as could be desired, except, possibly, for the fine iron dust produced by the wear of the rolling stock and rails. With regard to humidity the present conditions in the subway are most satisfactory. In lowering the inside temperature the humidity should not be materially increased. It may even be necessary to dry the air as well as cool it.

9. Renewing the Air.—Any plan for reducing the amount of heat must require a more positive renewal of air in all parts of the subway, than takes place under present conditions. This will affect the removal of a large portion of the fine dust. Again, the heat must be removed in such a manner as will interfere as little as possible with the conditions which now prevail in the subway in winter, because the comfortable warmth during this latter season is a desirable and attractive feature to the public; furthermore, if the method used results in a lowering of the temperature inside in winter to anywhere near the degree of cold outside, heat will have to be provided in the cars—this will require additional power for operation. Any means adopted should be entirely under control. It should be such that it may be applied with the greatest force at the time when its resulting effect will be most beneficial.

There are two ways of accomplishing the renewal. By forcing the air into the subway by creating a pressure at the inlet (the Plenum method), or withdrawing it by creating a vacuum at the outlet (the exhaust method). The most modern engineering practice suggests that the first method is preferable, under ordinary circumstances. The best results in tunnel ventilation have been accomplished by this means. As applied this method is commonly known as the Saccardo system of ventilation. If adapted in this instance, it would mean injecting cold, dry air into the subway behind trains, through properly proportioned nozzles located at points midway between stations. The air thus forced in would be discharged at the station openings.

In the subway, however, there are conditions which make this method objectionable. In addition to providing for the circulation of the cooled air, the air renewal is expected to remove a large proportion of the minute particles of iron liberated by the wear upon the rolling stock. By the Plenum method all the dust accumulated in the subway between stations would be forced to and out at the station openings. Also the fresh cool air entering at the interior points would become heated and charged with odors before reaching the outlets at the stations. From both of these causes the conditions of the air at the stations would be inferior to that between stations. This is contrary to the result desired—the air at the stations should be better. For this reason alone, then, the Plenum method should be rejected.

The only practicable manner of applying the exhaust method is to exhaust the air at points midway between stations, thereby causing the inflow of air through the station openings. By this means the freshest air is always secured at the stations. Such iron dust as may be liberated is also drawn into the interior and out through the exhaust openings there provided.

There are two mechanical means available for exhausting the air: The automatic louvres devised by Mr. Brink, and fans operated by electric motors. The louvres are movable and are operated entirely by the movement of the trains in the subway. They are so constructed that they will only open outward, and are balanced so that they always remain closed except when the interior air pressure is greater than that outside. The air pressure produced by a train as it approaches the openings in which the louvres are placed forces them open. An outflow of air is, therefore, induced, and continues until the train has passed the louvres, when they immediately close. The air necessary to replace that removed can be drawn in only through the station openings. By this means a flow of air (more or less intermittent) is produced through the station openings into the stations and thence through the subway to the interior outlets.

Since the operation of the louvres is dependent entirely upon the train movement, the volume of air removed by them during any time of the day will depend upon the number of trains moving during that period. From observations made upon those installed between the Columbus Circle and 66th St. stations, it was found that approximately 20,000 cu. ft. per minute were discharged through 100 sq. ft. of louvres during the hours of maximum train movement. From 1 to 5 a. m.—when very few trains were moving—only about 5,000 cu. ft. per minute were discharged through the same area.

If the air is to be renewed only for the purpose of ventilation, the installment of a sufficient number of

louvres would unquestionably bring about the desired results, for the volume of air renewed is nearly directly proportional to the number of trains operated; hence to the number of passengers carried. When, however, air renewal is desired also to aid in removing heat from the subway, train action should be supplemented by other devices especially during the night hours, when so few trains are operated, and the amount of heat liberated is at a minimum and the difference between the subway and the outside temperature is at a maximum, and when the greatest cooling effect by air renewal is obtained.

Again, at the present time there is no provision whatever for renewing the air in case the subway should become filled with smoke. Under such circumstances the signals would be obscured and trains would be stalled; the louvres, therefore, would not be operative. Fans should be provided for such an emergency.

Louvre chambers are considerably larger than fan chambers of an equivalent capacity; in consequence their cost of construction will be greater. It requires no additional power, however, to operate the louvres, while the operation of fans consumes considerable power.

To facilitate the action of the fans and louvres, more openings should be provided at the stations for the inlet of fresh air. The openings now provided through the entrances to the kiosks are at all stations greater than the clearway opening through the stairwells, in consequence of this the additional openings required must be made in the vault lights.

10. Cooling the Air.—To accomplish the cooling, no method has yet been fixed upon. The problem is so unusual and of such magnitude that no definite plan can be devised until extensive experiments can be made in the subway itself. There is absolutely no precedent to guide us. Nothing can be accomplished in this direction next summer, except in an experimental way. Several plans should be submitted to test under the summer conditions in the subway.

Three of the ways in which the cooling may be accomplished are: (1) By evaporation of water. (2) By refrigeration. (3) By disposing relatively cold water throughout the subway in such a manner that it will absorb the surplus heat without the heat coming in direct contact with the air. Ground water could be pumped for this purpose, and it might be cooled by some refrigeration.

Ample cooling effect could be accomplished by evaporation. The only objection to this plan is its possible effect towards increasing the humidity in the subway. Its exponents and opponents are equally positive with regard to this. What would actually occur can only be determined by an experiment during the summer, including several subway stations and the subway between them.

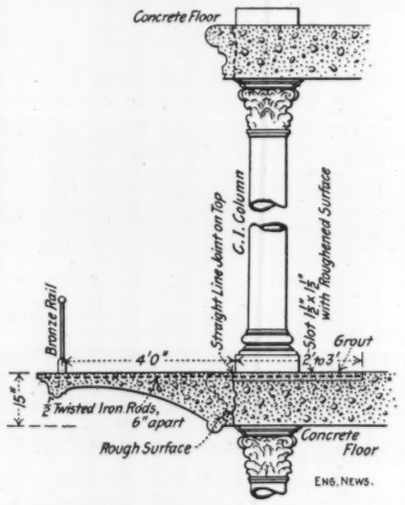
The application of refrigeration to this problem would far surpass anything ever before attempted in refrigeration. Refrigeration as adapted to air cooling for buildings is yet in an experimental stage, even where the air supply can, in a measure, be controlled. The conditions in the subway prohibit any control of the supply. It is doubtful, therefore, if satisfactory results could be attained. Several studies have been made, based upon as many different methods of applying refrigeration, assuming that the maximum possible average heat dissipation may amount to 45,000,000 B. T. U. per hour. Again, however, as with the evaporation plan, the effectiveness of any refrigeration method can only be determined after experiments have been made during the summer months.

The possibilities of the third method of cooling were suggested by Mr. J. E. Starr, with whom we have had some conferences. No studies have been made upon this plan. It would probably cost more than the evaporation method and certainly less than ordinary refrigeration.

REINFORCED CONCRETE AND FIREPROOF CONSTRUCTION IN THE SAN FRANCISCO DISASTER.

By Maurice C. Couchot.*

There were but few examples of reinforced concrete construction in San Francisco and its vicinity at the time of the earthquake of April 18. It has been assumed that this construction was prohibited by the building ordinances of the city, but this is an error. While these ordinances did not contemplate or provide for reinforced concrete construction, they also did not prohibit it. It was true, however, that opposing interests were strong enough to prevent reinforced concrete being much used in building work; only in one instance was a permit issued for such a structure. This was the 6-story warehouse of the Bekin Van & Storage Co., which was in course of construction at the time of the earthquake.



Detail of Balcony in Academy of Sciences Museum.

The warehouse mentioned was being built of brick walls, with interior columns and floors of reinforced concrete. The columns had hooped reinforcment, the beams were reinforced with Kahn bars and the floor slabs had a reinforcement of twisted bars running in both directions. The arrangement of the girders gave floor panels about 15 × 16 ft. The effect of the earthquake on the building was to shatter the brick walls so that something like one-half of them will have to be rebuilt and to do no damage to the reinforced concrete work. As to the conflagration damage, only one panel of the second floor had been exposed to fire and here the concrete on the bottoms of the beams and slabs had peeled off, as was to be expected of concrete only two months old.

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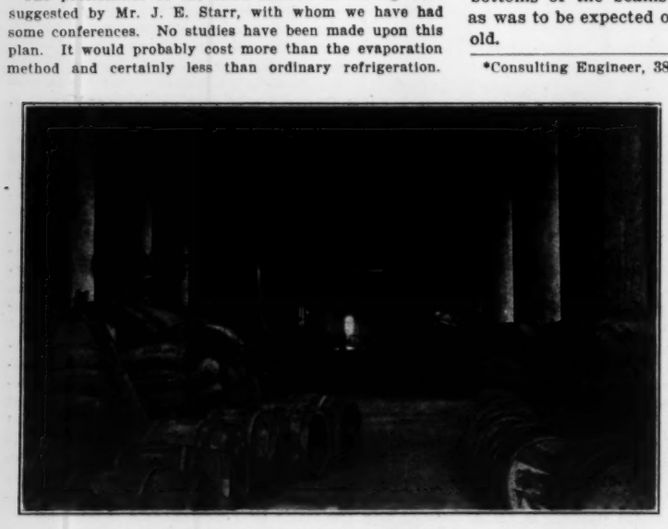
In the Academy of Sciences building on Market St., part of the structure used as a museum had brick walls and cast iron columns supporting a reinforced concrete beam and slab floor. The accompanying interior view of the museum shows the central court with the projecting balconies. These balconies were not a part of the original construction but were added in 1898 and were of the construction shown in the sketch. The original building was constructed in 1890. The floor slabs and girders are reinforced with Ransome twisted bars, and the girder bars passed through cast lugs on the columns and were fastened behind. The building as described went through the earthquake and was entirely gutted by the fire; the brick walls were completely shattered, but the columns and floors remain intact.

A still earlier example of Mr. Ransome's work was the Alameda Borax Works, built in 1888. This was an all-concrete structure, foundations, columns, walls, floors and roof all being of reinforced concrete. The building was 180 × 40 ft. in plan and three stories high; it had two rows of wall columns and a single row of interior columns, giving a column spacing of 20 ft. in both directions. Main transverse and longitudinal girders were carried by the wall columns and these girders carried beams two in each bay at right angles to the transverse girders. The floor slabs were 3 ins. thick and the walls were 12 ins., 10 ins. and 6 ins. thick. The site of the building was on a sandy mud and the footings were carried down some 6 to 8 ft., and the walls above the footings to the first floor level were reinforced as girders between columns. This building withstood the earthquake shock without damage; it was not subjected to fire.

In addition to the preceding structures the writer may mention the following reinforced concrete building work that is as solid to-day as it was before the earthquake: Folger Building, with floors and beams reinforced with corrugated bars; Monadnock Building, with floors and beams reinforced with corrugated bars; Martin Station and Marysville Public Library, with columns, girders and floors reinforced with Kahn bars; the P. & B. Paint factory, entire building reinforced with corrugated bars; a private residence, Burlingame, reinforced with round rods, the buildings of the Selby Smelting Co. and the Bowers Rubber Co., and the water reservoirs of St. Quentin prison.

In bridge work, the Pollasky Bridge and the Ripon Bridge, reinforced with corrugated bars, and the Stockton Bridge, reinforced with Kahn bars, suffered no injury from the earthquake. In the city all vaults of reinforced concrete preserved their contents intact. Indeed, of all the building materials that came to the writer's notice concrete made the best record in both earthquake and fire.

Regarding other materials it may be noticed that tile floors and partitions failed generally. Some magnificent buildings, like the Mills Building, the Crocker Building and the Flood Build-

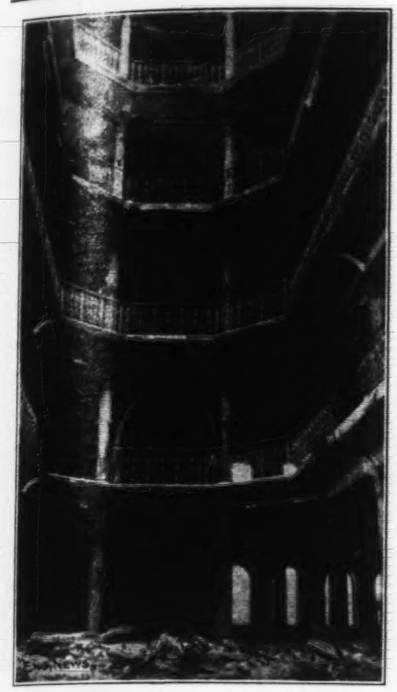


INTERIOR VIEW IN ALAMEDA BORAX WORKS, ALAMEDA, CAL., AFTER EARTHQUAKE.

(This structure was erected about 18 years ago by Mr. Ernest L. Ransome with reinforced concrete columns, floors and walls.)

INTERIOR VIEW OF REINFORCED CONCRETE WAREHOUSE FOR BEKINS VAN & STORAGE CO., OF SAN FRANCISCO, CAL.

(This building was under construction, two stories only having been completed at the time of the earthquake.)



Interior View of Museum of Academy of Sciences Building, San Francisco, Cal., after Earthquake and Fire.

(This structure was erected some 20 years ago by Mr. Ernest L. Ransome, with cast iron columns and reinforced concrete girders, floor slabs and balconies.)

ing were entirely ruined inside because tile was used for the interior construction. Plastered metal partitions also failed, and marble wainscoting and floors went to pieces. Turning to the exterior we have a repetition of the record of the Baltimore fire. Marble, sandstone and granite all spalled where exposed to heat. Terra cotta trimming cracked. Red brick failed, generally due to poor workmanship, poor bonding and poor mortar. Pressed brick stood best of all when properly bonded. In one case the writer saw a pressed brick veneer stripped entirely from the backing from the first to the twelfth story; the brick, while of good quality, were bonded to the backing only by a clipped course every tenth course. Such construction was a menace to life at any time, earthquake or no earthquake, and the clipped course bond for brick veneer should be absolutely prohibited. Terra cotta decoration stood fairly well when well burned and not too highly ornamented, and where strongly built and well filled and anchored, but when any of the above factors was lacking the material failed entirely.

It is probable that the same conflagration conditions will never again exist in San Francisco. The fireproof buildings were absolutely unprotected from exterior fires. They were in most cases surrounded by very inflammable buildings which gave intense heat in absence of water to quench the flames. In such contingencies no construction can be said to be fireproof. Iron shutters did not do their work as expected. The writer found that metal sash and wire glass is a better protection than iron shutters, as such shutters are now made.

In conclusion the writer offers the following suggestions for fireproof construction: All steel in steel cage construction should be embedded in concrete; all floors should be of reinforced concrete; all hall partitions at least should be of cinder or slag concrete; no wood frames should be permitted in hall partitions nor any wood trim, doors or sashes; sashes should be glazed with wire glass and made of metal; chair rails and picture molding should be fastened with metal ties and not to wooden grounds, which cut the partition in two; and even wooden flooring in steel frame buildings should be replaced by some non-combustible substitute. The cost of steel frame buildings thus built would not be greatly increased and the increase would, the writer believes, be a profitable investment.

EXTRACTS FROM THE MINORITY REPORT OF THE SENATE COMMITTEE ON THE TYPE OF THE PANAMA CANAL.*

VIEWS OF THE MINORITY.

The undersigned members of the Committee on Interoceanic Canals beg leave to submit, as a minority, a report upon the bill (S. 6191) "to provide for the construction of a sea-level canal connecting the waters of the Atlantic and the Pacific oceans, and the method of construction," and to recommend that the bill do not pass.

There can be no doubt whatever that the Spooner act authorizes the President to build the canal, and therefore authorizes him to fix the type of the canal which is to be constructed. It can not be questioned that when the Spooner act was passed it was the intention of Congress that a lock canal should be constructed, and the financial provision made in the act lends support to this view; but the authority to decide the character of canal is left to the President. The President, having taken the advice of competent engineers and of the Canal Commission, has recommended that it is advisable to construct a lock canal. The question presented by this bill is whether Congress shall annul the action of the President, taken under its authority, or shall simply hold its hand and allow the President to exercise the power which it has heretofore conferred upon him. The evidence given before your committee shows that the President's opinion was right, and it entirely fails to justify the passage of the bill proposed.

THE LOCK CANAL PROJECT.

The great problem in the construction, operation, and maintenance of a canal across the Isthmus is in the control of the Chagres River and its tributaries. The large lake, which we shall call Lake Gatun, meets this difficulty by offering an ample reservoir of 118 square miles for the flood flow of the Chagres and all its tributaries without in any way raising the level of the lake more than a few feet. It also places the mouths of the streams discharging into the lake so far away from the ship channel through the lake as to make it altogether unnecessary to do dredging.

The Chagres River strikes the dead water of the lake, under this plan, some eight miles from the channel, and all sediment and drift, of which there is very little in the Chagres River above Gamboa, where it strikes the line of the canal, would be deposited so far away from the canal as not to require its removal by dredging. The streams that empty into the lake below the Chagres and to the north of it are a number of miles away from the channel. The cost of the canal is $140,000,000. This includes everything but the sanitation, and it, of course, includes the equipment already purchased and preparation for construction already made.

The central feature of the plan is the dam and locks at Gatun. Some question has been made in the evidence before the committee by certain witnesses, of the stability of this dam, but the evidence is overwhelming that the dam will be as firm as the everlasting hills. In fact, it is of unprecedented size and weight, and is to be in effect a small mountain made by man—more than a mile long, half a mile thick at the bottom, and rising to a height of 135 ft. The normal water level is 85 ft., and at this point the dam is 374 ft. thick. The dam above the water level rises 50 ft. farther to a crest 100 ft. across.

The pressure against a dam is measured not by the area and volume of the water which it upholds, but by the height of the water against the face of the dam. The weight of the Gatun dam is *sixty-three* times the pressure of the water against it. There is no dam known anywhere in which the proportion of resisting power to the weight of the water is as great as it will be in the Gatun dam. In other words, the minority of the consulting engineers having the material with which to construct the dam in the immediate neighborhood, found it possible, without greatly increasing the expense, to enlarge the proportions of the dam far beyond the requirements of safety in order to secure absolute certainty and solidity.

Only two expert witnesses before your committee attempted to question the stability of the dam. They were so extreme in their statements in this and other regards to which reference will hereafter be made that the weight of what they had to say is much affected by the partisan character of their expert opinions. Other witnesses for the sea-level canal—Mr. Parsons, of New York, and Mr. Hunter—in effect concede that the dam will be stable. Mr. Parsons says that were it a private enterprise with a prospect of 5 or 6% dividends he would advise clients properly affected by considerations of cost that the lock plan was feasible, but he thinks the Government should spend more money and time, and get, what he thinks, is a better canal in view of the Government resources.

Science with respect to the erection of earth dams has progressed in the last ten or fifteen years to a point of knowledge that was altogether unknown before. There are three ways by which a dam can be overcome: First, by overflowing the top; second, by percolation through the substance of the dam; and third, by percolation underneath. No one contends that there is any danger that the water will overflow the top of this dam, which is 50 ft. above the water level of a lake 118 square miles in superficial area.

It is proposed to construct this dam by what is called sluicing; that is, by pumping the material mixed with water into the proper place and allowing the water to run off, thus hardening and producing great solidity in the material which is left. This is a well-known method of building a dam and makes it absolutely water tight. Even the most extreme partisan opponents of the lock-level plan have not intimated that a dam thus built half a mile thick would permit percolation through it.

QUESTION OF PERCOLATION.

The only question that is raised is as to percolation underneath the dam. The dam is 7,700 ft. long. Of this 7,700 ft., rock, sometimes called indurated clay (which resembles soapstone and which, though it has been exposed to the weather in a dry dock at Colon, shows no signs of erosion or abrasion), comes within 20 or 30 ft. of the surface at every part of the dam except at two places, at which there are depressions in this rock running down to 200 ft. in one case and 258 ft. in the other. These depressions are filled with mixed sand and clay for from 150 to 200 ft. in depth, and of a material substantially impervious to water.

At the narrow bottom of each depression in the inverse apex of each, as it were, however, some 200 ft. down, is sand and gravel, porous and water bearing. The borings in two instances, at a depth of 32 ft. in one case and 60 ft. in the other, showed an overflow at the pipe of one-quarter of an inch; but all the other borings showed the water only as has been said, at a depth of substantially 150 ft. It is quite clear that the water in the two shallower borings was not from the river and was not from a stream.

The water could not have come from the river, for the reason that the pipe was some 10 ft. above the surface of the river and the river is at sea-level as far up as Bohio, some 10 miles above. It must, therefore, have come from some pocket in the neighboring hills. The question, therefore, to be answered is whether there is the slightest danger to the stability of the dam or the retention of water in the lake due to the fact that below a blanket of impervious material at least 150 ft. thick, there is some porous material between the overlying blanket and the rock. Just how the water from the lake could penetrate the impervious blanket above is not explained by any witness. Even if there were danger of this, it is a matter easily taken care of by sinking pipes into this comparatively narrow part of the dam where this porous material exists at the bottom of the depression 200 ft. down and squirting liquid cement, or grout, into this material, and thus making it impervious.

Another method of cutting off any danger of seepage would be the use of steel sheet-piling, which could be sunk as deep as required, even to the bottom of the deepest part of the depression in the rock. Mr. Stearns, who is the chief engineer of the Metropolitan Water and Sewerage Board of the Commonwealth of Massachusetts, has constructed a dam or dike two miles in length wholly of earth at Wachusett, Mass., to uphold a pressure of water 65 ft. over soil much more porous and variable in character than that which the borings show to be in these two depressions under the Gatun dam and in which the depth to rock is greater in some places than the depth of the depressions in the rock under the Gatun dam.

The other dams necessary in the lock-level plan, which make Lake Sosa, are to be constructed on clay and mud entirely impervious to water and only 40 ft. above rock. They are of such size and weight that there is no doubt of their stability. Of course, they could have a stone core carried down to bed rock, but the stone core in an earthen dam is of doubtful utility. Engineers differ seriously as to the added strength that comes from a core in such a dam. The union of the masonry with the earth has in practice not proved always to be satisfactory.

The truth is that the calculation by Mr. Stearns, the greatest authority on dams and infiltration in this country, and probably now in the world, shows that even if the whole material below the dam at its whole length were clean sand prepared for the purpose of filtration, the pressure would not be sufficient to cause a percolation of more than 10 cu. ft. to the second—an amount which would be negligible for the purpose of reducing the size of the lake, and which could have no effect whatever upon the material in or under the dam.

It has been suggested that, in view of the depth of the sand and clay in the depressions under the Gatun dam, that part of the dam covering the depressions would settle more than the dam at other places, and that

*The majority report, favoring the sea-level plan, was published in the issue of May 24.

this would produce a fissure, letting out the water. This criticism is of no weight, for the reason that the settlement such as would take place under the great weight of the dam would go on during the entire seven or eight years of construction, before any water would be let into the dam, and, therefore, before any such results as that proposed could follow. The settlement, as already said, would, of course, tighten the material under the dam and make it even more impermeable than it is proven to be by the borings. At the same time—in the period of construction—substantially all the inequalities of settlement, except what would be negligible, would have taken place.

Objection was vigorously made by some of the witnesses to the Gatun locks, on the ground that the proposed site did not have rock foundation of sufficient length and width to construct locks of the size required by the lock-level plan. This objection, though earnestly urged by a number of engineering witnesses, faded into nothingness upon receipt of cables from Chief Engineer Stevens, who had directed 100 borings to be made and reported that there was not only rock foundation extended enough for three locks, each 900 ft. of usable length, but that there was room enough with solid foundations, as if specially fitted by nature, for three locks, each 1,150 ft. of usable length.

ONLY TWO LOCKLESS CANALS.

General objection is made to the use of locks at all in a canal in which large ships are to be carried from one ocean to another. There are two ship canals in which there are no locks. One is the Corinth Canal, which is only two miles in length, and the other is the Suez, about 104 miles in length. All the other large ship canals, including the Manchester Ship Canal, of 60 miles in length; the Amsterdam, or North Sea Canal, of 15 miles in length; the Kiel Canal, of 60 miles, and the Sault Canal, the canal proper being but two miles in length, but the dredged channel through the St. Mary's River, amounting to 40 miles in length, have locks. The Manchester Canal has four locks; the Kiel Canal, two locks (tidal) at each end; the Amsterdam, one tidal lock, and it is proposed to have one tidal lock at Panama.

At the Sault Canal there is one lockage in a passage from Lake Huron to Lake Superior. There is the Weitzel lock, with chamber 515 ft. with 80 ft. width, narrowing to 60 ft. at the gates; the Poe lock, 800 ft. long and 100 ft. in width, and the Canadian lock, 900 ft. long and 60 ft. in width. The lift of the locks at the Sault is about 20 ft. The lift of each lock at Gatun is 28½ ft. The tonnage of shipping passing through the Sault Canal during the eight months of the season of last year was three times that of the vessels which passed through the Suez Canal during twelve months of 1905, and the average size of the vessels passing through the Poe lock was only 10% less than that of the vessels which passed through the Suez Canal, while it was over six times that of the vessels passing through the Manchester Canal.

It is not necessary to give the tonnage that passed through the Manchester Canal or the Kiel Canal or the North Sea Canal, but it is sufficient to say that these canals carried a large commerce of good-sized vessels. It is therefore beyond dispute that the lock system of navigation has been demonstrated to be practicable by 50 years of experience at the Soo and other canals, and by the enormous tonnage which passes from Lake Superior to Lake Huron and back again. There are canals with flights of locks, and others with locks of 30 ft. lift, and the Deep Waterways Board, appointed under an act of Congress to make plans for a canal from Lake Erie to Lake Ontario by way of Lockport, recommended a flight of locks for ships, the lift of which was 40 ft. Certainly the mere extension of a lift in a canal lock from 20 ft. to 28½ or 31 ft. can not be characterized as unprecedented or experimental when it calls for the application of no different principle and merely enlarges by 33⅓% the dimensions of a device known for centuries.

LOCKS IN FLIGHT.

Objection is made to the fact that the locks are in flight; that is, that they are placed in tandem so that a vessel ascending can move from the water at highest level in one lock immediately into the low level of the next lock. Locks thus arranged in flight or in steps, so to speak, are well-known devices in lock construction and are no more of an experiment than a single lock. The previous commissions—the Commission of 1899-1901 and the previous French commission—recommended locks in flight, and such was necessarily the recommendation of the minority of the Interoceanic Canals Committee upon which Congress acted in passing the Spooner act.

The objection urged to the locks as a whole is the possibility of delay due to trouble with lock machinery, the danger to both the vessels and the canal by destruction of the gates which hold back the water of the upper level, due to negligent management of the vessel in entering or leaving the locks, and finally the delay of commerce caused by passage through the locks. As to delays occasioned by difficulty with machinery, the history of the Soo Canal demonstrates that it is entirely possible to install and maintain a system of lock machinery which will work with the utmost smoothness, and that delays in the Soo Canal from this cause are much less in number and extent than those arising from groundings of vessels in the Suez Canal.

Coming to the danger of breaking through lock gates and thus draining the water of the canal and sending the vessel to destruction, we can again refer with satisfaction to the experience at the Soo Canal. The Soo locks have been in operation either under the State of Michigan or under the United States for more than fifty years, and in that entire time there have been only three accidents in which the vessels passing through the locks collided with the gates, and in no single one of these accidents was there any other than a temporary damage to the gates. The system of bringing vessels into the lock under complete control is so certain and well regulated, and so much better at the Soo Canal, and offers so much more precaution against accident than the practice prevailing in the European canals, that the liability of accident is practically excluded.

The locks projected at Gatun and at the other places in the lock-level canal have approach walls 1,200 ft. long at each end, through which vessels approaching the locks proceed at but a mile an hour, with their speed regulated by lines thrown out to snubbing posts, following in this respect the course taken at the Poe and other locks of the Soo Canal. The greatest confidence can be reposed in the evidence upon this point given by two members of the Board of Consulting Engineers, Mr. Noble, the dean of American engineers, who was for twelve years in charge of the Soo locks, and by Mr. Ripley, who is now in charge of the Soo locks.

But it is said that there were three accidents of this character in the Manchester Canal, in which, through a failure to give proper signals, the lock gates were forced open; but the gates behind were shut in time to prevent injury to the locks, and the steamers were not particularly injured. They had no approach walls at Manchester, a great and necessary instrumentality in securing slow and regulated approach, and they had not double gates, which would have made the accident impossible. Such double gates are provided at the Soo locks.

The lock-level plan under consideration provides for a double set of gates at the highest level lock. These gates at each end of the lock are 80 ft. apart, with water between when the locks are full. A vessel entering the lock from above, therefore, would have first to break through two gates weighing more than 450 tons each, with a cushion of water 80 ft. long, 30 ft. high and 90 ft. wide, and then break through a second set of gates of the same weight and size. A vessel bound up would have to go through two gates thus supported, and in addition overcome the resistance of the water against the outward upper gate.

NAVIGATING THE LOCKS.

It is said that the mere loss of or injury to the steamer would not be the extent of the disaster, but that if the double upper gates were broken down, then there would be no method of stopping the outflow of the water from the lake for at least a depth of 30 ft. In spite of the extreme improbability of any such accident, as already shown, the Commission has allowed $2,000,000 for movable dams of a character similar to those employed at the Sault, which could stop the flow through the locks if any such remote and unlikely disaster were to occur.

Since the hearings Mr. Hunter, who, as a member of the technical commission of France, had previously reported in favor of a lock canal with a flight of two locks at Bohio not very much less in size than the locks in the present lock type, has filed a communication with the committee in which he holds up for the consideration of the Senate the danger to the locks and the shipping in the operation of the locks of the Gatun and other dams.

One of the questions which naturally arises in view of the extreme statements of Mr. Hunter is, how it could come that Mr. Noble, who is the dean of the American engineers, and who for twelve years had charge of the Sault locks, where there are in operation four different locks of large size, and where under their observation went on a still larger lock on the Canadian side, could have recommended the structure which meets such condemnation at the hands of Mr. Hunter, who had himself recommended a similar construction for the Panama Canal in 1898. The difference in the experience between the Manchester Canal and the Sault Canal in this respect is sufficient to demonstrate the fact to be as Mr. Noble and Mr. Ripley state it to be, to-wit, that sufficient precautions and instrumentalities have not been adopted in the management of the Manchester Canal to avoid the accidents described, and which have prevented those accidents in the Sault Canal. All these precautions are projected in the present lock canal. The very extravagance of Mr. Hunter's statements would seem to show him to be affected by the odium scientificum.

The remaining objection to the locks is the time taken in passing them. A careful estimate made by Mr. Noble and Mr. Ripley is that it would take about fifty minutes for a vessel to pass through each lock, or rather that there would be an interval of fifty minutes between the time when one vessel would enter the locks and another vessel might enter them, while the time taken in passing through the three locks would be two hours and nineteen minutes, with an equal interval in passing from the 85-ft. level down to the other. But this is more than made up by the speed which in the lake navigation the steamer can make in the broad channels of the canal, so that it would be found in heavy traffic the large steamers could traverse the canal from one side to the other in from nine to ten hours.

TONNAGE CAPACITY OF A LOCK CANAL.

The lock-level plan is estimated by the majority of the Consulting Board of Engineers to have an annual capacity of passing 80,000,000 tons of shipping through the canal, dependent upon the supply of water from the Chagres for the lake. After the tonnage reaches 60,000,000 or 37,000,000, it would be necessary against the drain of a dry season to store more water in a dam at Alhajuela, eight miles up the Chagres River, at the point of its junction with the canal path, which could be erected for upward of $2,000,000. The Isthmian Canal Commission makes a more moderate estimate of the canal capacity at from 50,000,000 to 60,000,000 tons. It is hardly material which is the more likely estimate for the reason that if the tonnage of the canal begins the first year at 7,000,000 tons and increases at the same proportion that the tonnage of the Suez Canal has increased, and we know no substantial reason why we should look for any greater increase, the tonnage in the year 2000 will be 35,000,000 tons, assuming that the canal is ready for operation in the year 1915.

If it were necessary to increase the capacity of the lock-level canal it could be most easily done by the erection of additional locks of a larger capacity and by increasing at comparatively small expense the depth in the harbor channels and the width in the 4½ miles of the 200-ft. channel. The increase in the lock capacity is the only increase that would be really necessary, for the lake navigation is practically limitless now.

We have thus described and considered the objections to the lock plan decided upon under the authority of the Spooner act. We are strongly of opinion that this is not only a feasible plan, but that it will in the least time and for the least money furnish a canal which will offer safe and speedy passage for the largest ships now sailing or building or in reasonable contemplation.

THE SEA-LEVEL PROJECT.

The land part of the sea-level canal will be 19.47 miles 200 ft. in bottom width and 20.39 miles 150 ft. in bottom width, with the tidal locks 0.59 of a mile. The excavation for this canal will require the removal and deposit of 250,000,000 cu. yds. of earth and rock. Of this, 110,000,000 cu. yds. will be in the eight miles through the Culebra Cut, a very considerable part of which is rock, and hard rock at that, as the excavation goes deeper.

The great problem which led all previous commissions, including two of the present majority of the Consulting Board, to vote against the sea-level project, was the Chagres River and the difficulty of providing for the dangers due to the frequent occurrence of freshets and floods in that river and its tributaries during the rainy season of some seven or eight months of each year.

It was only necessary for the majority of the Consulting Board to make provision to divert this water from the canal in a way which should prevent the introduction into the canal of dangerous currents which would overwhelm ships in the canal and make navigation impossible. The method by which this is proposed to be done is, first, to erect a dam at Gamboa of masonry, or earth with a masonry core, 2,200 ft. long and 180 ft. above mean sea-level, or 130 ft. above the river bed, so as to dam up the waters of the Chagres and form a lake some 15 or 20 miles above Gamboa. A spillway is also provided by which in floods some 15,000 cu. ft. per second will be discharged from this lake into the canal. In addition to this dam it is found necessary to erect three other dams, one to shut off the waters of the river Caño, another the waters of the river Gigantito, and the fourth the waters of the Rio Gigante. These dams have to be high enough to back the waters of the streams which they dam in a lake to a point where the water will flow over the height of land in a direction which shall take the water permanently away from the canal. The dam to close the Gigante will be 2,800 ft. long; that to close its main tributary, the Gigantito, will be about 490 ft. long, and that to close the Caño about 820 ft. long; the height in each case being about 75 ft. above the ground, the depth to which the foundations must be sunk being unknown. A dam 535 ft. long and 25 ft. high will be required to close the depression in the rim of one of the lakes. In addition to this the diversion channel partly constructed by the French is to carry off the water of the Rio Gatun and also of the Rio Mindi and discharge it into the Bay of Manzanillo. It is conceded by the Consulting Board that the amount of water to be let into the canal during the wet season will make a current between Obispo and the shores of Limon Bay varying from a mile an hour to 2.61 miles, according to the rainfall and flood. The height from which this water is let into the canal from sixteen or seventeen streams over masonry aprons or through metallic discharge pipes sloped and lowered so as to prevent objectionable currents at junction points varies from 13 to 165 feet.

SAFE NAVIGATION OF LARGE SHIPS.

It may be said truly that a canal which does not provide at all times safe navigation for the larger ships is not a compliance with the intention of Congress, expressed in the Spooner act, and is not in accordance with a proper policy in the construction of the canal. It seems to us that the figures show that with a canal twenty-one-fortieths of which is 150 ft. wide and nineteen-fortieths is but 200 ft. wide, with a curvature from three to four times that of the Suez Canal and with the liability to a current which in the Suez Canal prevents the safe steering of the larger vessels, does not afford the safe and convenient passage required by the statute and public policy.

To the criticism of the curvature of the sea-level canal answer is made that the curvature of the lock canal is greater than that of the sea-level canal. A moment's examination of this statement will show how unsatisfactory such an answer is. The length of curves in the lock-level canal is only 15% of the total length of the canal, while that of the sea-level is 38%; and while the degree of curvature is greater in the lock canal than the sea-level, the curves are almost wholly in channels 1,000, 800 and 500 ft. in width, in which such curves have not the slightest effect to increase the dangers of navigation. It is true that in the wide channels of the lock-level canals the corners to be turned are made sharper than in the very narrow sea-level canal, because this is in accord with the practice of navigation in our great lakes and harbors.

Where there is plenty of sea room, as in the lock canal, the best method of laying out courses is long straight stretches with greater angles in the changes of course. This secures greater speed than in longer curves, and in such width of channel as there will be in the lock canal there is not the slightest danger or difficulty of navigation in making the angles sharper. But these questions of percentage of length of curve and of degree of total curvature are of the highest importance in considering whether a canal only 150 ft. in width may be navigated in rapid and cross currents.

The usable length, depth over the miter sills, and the width of the locks of the lock canal measure the size of the vessels that can be carried safely through that type of canal. The locks have a usable length of 900 ft., a depth of water over the miter sills of 40 ft., and a width of 95 ft. This will provide safe entrance and elevation to a ship having 25% more tonnage than the large Cunarders now building, and there is not the slightest danger that these vessels may not proceed at from nine to ten miles an hour through every part of the lock canal projected, except the 4.7 miles through the Culebra cut, where they would have to proceed slowly under check in a depth of water 5 ft. greater than that of the sea-level canal, and of the same width, to-wit, 200 ft.

In the so-called sea-level canal there is a lock called the tidal lock at Sosa, which it will consume an hour for each vessel to pass through. It is said that this tidal lock will be open more than half the time, but the statement is not borne out by the facts with reference to the Kiel Canal, which has a tidal lock, and where the fluctuations of the tide are not as great. The gates of this lock are habitually used for the passage of vessels. The explanation of this is simple: The lock chamber constitutes a sudden contraction of the channel in which all currents are necessarily greatly increased.

It seems clear to us that, taking the two canals as instrumentalities of transportation, the lock canal is much to be preferred to the sea-level canal of 150 ft. or 200 ft. in width as projected by the majority of the Consulting Board and recommended by the committee.

DANGER FROM EARTHQUAKES.

The danger from earthquakes to either type of the canal was considered at the time of the question between the Panama Canal (which was then regarded as a lock canal) and the Nicaraguan Canal, and the danger was certainly not treated as a very serious one in view of the decision of Congress. The attitude of the Senator who submits the report of the committee with respect to earthquakes* was shown on the 23d of January last in the examination of the chief engineer, Mr. Stevens:

Senator Kittredge.—Do you know of any earthquakes having occurred in that country?

Mr. Stevens.—I have not got any record of any earthquakes. We have an earthquake machine at Ancon—that is, at Panama; but it has only been running for a few months.

Senator Kittredge.—Did you ever see the straight arch in the old church at Panama?

Mr. Stevens.—Yes, sir.

Senator Kittredge.—Do you know how long that has been there?

Mr. Stevens.—I suppose two hundred years or more.

Senator Kittredge.—Any serious earthquake would have destroyed that, would it not?

Mr. Stevens.—Well, that is a mystery to me how it stands. I have heard the explanation, but it does not satisfy my mind. I can not explain it from an engineering standpoint why it does stand.

Senator Kittredge.—Is not that quite a convincing argument that earthquakes never happen at Panama?

Mr. Stevens.—Decidedly, to my mind. I cannot conceive of an earthquake of any severity at all but what would destroy that arch.

*Senator Kittredge; see p. 582 Engineering News, May 24.

Senator Kittredge.—So that there is not any danger of the dam at Gamboa being destroyed by an earthquake?

Mr. Stevens.—I would not say that there was no danger, but I suppose there is no place in the world but what is liable to have an earthquake. That is one reason why I made the statement this morning that I preferred an earthen dam to a masonry dam anywhere, because I do not think an immense earthen dam could be destroyed by an earthquake.

Certainly, as pointed out by Senator Kittredge in the above statement, the history of Panama shows that earthquakes are not of frequent occurrence at the Isthmus and that violent earthquakes have never thus far happened at that point.

The awful character of the catastrophe at San Francisco is liable, of course, temporarily to destroy one's sense of proportion in this respect, but certainly in passing upon a question of this character we should not allow the slightest element of hysteria to enter into our decision.

In the next place, the relevancy of the question here is not whether an earthquake might be very destructive to any canal, but whether it would be more likely to destroy the lock canal than the sea-level canal. The lock canal has a dam at Gatun, a dam 135 ft. high, supporting a column of water of 85 ft.; it has also a small dam at Pedro Miguel, some 40 ft. high, and a series of three dams or dikes, making up Lake Sosa at the Panama terminus of the canal. These dams are all to be earthen dams, of great width, and thickness, and weight.

If dams are to be affected by the earthquake, in what respect does the sea-level canal differ in vulnerability from the lock canal? For we have in that construction, absolutely necessary to the preservation of the sea-level canal and its operation, a masonry dam at Gamboa 2,200 ft. long, 180 ft. above the sea level and supporting a head of water of 170 ft.; we have at Gigante a dam 2,800 ft. long, supporting a height of water of at least 70 ft.; we have on the River Caño a dam 890 ft. long, supporting a pressure of water of at least 70 ft. in height, and a similar dam on the River Gigantito 490 ft. in length and supporting water of a height of at least 70 ft.

The sea-level plan has also a tidal lock at Sosa, together with a number of spillways and other masonry structures, all of which are essential. It is evidently, therefore, futile to argue that a destructive earthquake would be any more destructive to a lock canal than it would be to a sea-level canal if it ever came to Panama.

Coming now to the San Francisco earthquake and its results, we may truly say that instead of furnishing a sound argument based on earthquakes against the lock canal it offers, as nearly as any such occurrence at another place can, a demonstration of the remoteness of the danger from earthquakes to the lock-level canal or, indeed, to either type of canal. It so happens that in his most satisfactory and conclusive argument in respect to the stability of the Gatun and Sosa dams Mr. Stearns, the world authority on hydraulic filtration and the stability of dams, referred to two California dams, the construction and the experience of which had shown the entire utility, advantage, and solidity of earth dams and justified in every way the plan of construction of the dams projected for the lock-level canal.

The method of construction, the weight and dimensions and sketches of these dams were contained in the report of the minority of the Consulting Board of Engineers, and were shown not to be proportionately so heavy and solid and stable as the Gatun and Sosa dams. These dams were within the territory in which the greatest destruction was caused by the San Francisco earthquake. These two were the San Leandro dam, which supports a column of water 115 ft. high and is composed all of earth and is the highest earth dam in water level in the world. It is the dam used for maintaining the reservoir for the water-works of Oakland, Cal., and is situated 5 miles east of San Francisco Bay. This dam was wholly undisturbed by the earthquake. Its weight and size are far less in proportion to pressure of water against it than any of the dams of the lock canal. The other dam, also a wholly earthen dam, and supporting a pressure of water 90 ft. high, is called the Pilarcitos dam, and supports one of the reservoirs of water used in the water supply of San Francisco. The most startling feature of the San Francisco earthquake was a fissure or fault by which one great stratum or layer of the earth's surface moved on another great layer along the path of an old geological fault. This fault extended in a northwesterly direction along the peninsula upon which San Francisco is situated, and this it was which cut off the water pipes of the city and destroyed the trestles and other structures in its path. This fault or fissure movement went through one end of the Pilarcitos dam and cracked the ground in the neighborhood and destroyed a number of buildings, but the dam was wholly uninjured, and no water whatever was lost from the reservoir that it protected.

The San Andreas dam, another dam of the same system and of a similar construction to that of the Pilarcitos dam, all of earth, was in the line of the fissure and the greatest earthquake movement, and it, too, remained entirely unaffected and retained all the water behind it. If anything could be demonstrated by these three instances, it is that earthen dams of mountain or hill size, like those of the dams in the lock plan, are not subject to destruction by earthquake. But the inference to be drawn in favor of the stability of the structures of the lock plan at Panama from the lesson of San Francisco does not stop with the earthen dams.

Everywhere within the influence of the earthquake it has been demonstrated that the question whether buildings and structures above the ground and supported only by their own walls will stand the thrust and shock of a violent earthquake depends upon the character, care, and scientific construction. The highest buildings in San Francisco made of concrete with steel frames were unaffected by the earthquake, while the buildings made of lime-mortar and improperly constructed were totally destroyed.

And this brings us to the stability of another dam in San Francisco, which was only a quarter of a mile from the line of the fissure and fault already referred to, made of concrete 115 ft. high above the natural surface of the Crystal Springs reservoir. The reservoir at the time of the earthquake was full. This dam was subject to a series of thrusts and pulls in vertical planes along its length, since it is parallel to the fault line, and so far as Professor Derleth, professor of structural engineering in the University of California, could see, and he observed the dam carefully, there is not the slightest crack. No water has escaped from it. There is no mass of masonry in the United States that is more like the masonry of the proposed locks at Panama than the Crystal Springs dam.

A full account with respect to these dams will be found in two letters from Mr. Stearns to the chairman of this committee, inclosing an article written for the Engineering News by Professor Derleth, and as the matter has been given so much importance we attach these letters to this report as an appendix.

The attack made upon the stability of the Gatun locks in an earthquake is wholly unfounded, when the character of the locks is considered and the tremendous strength of construction that they will have. The locks are to be wholly inclosed in Gatun Hill, to rest on rock foundation, the foundation of rock below the miter sills being nowhere less than 6 ft.

The average thickness of the side walls is to be 40 ft., increased at the gates to 45 ft., and the average thickness of the center walls is to be 53 ft. The height of the walls above the foundation is about 80 ft., varying with the different depths of foundation. The total length of masonry in the three locks is 3,135 ft., and the total width occupied by the twin locks is 323 ft. The concrete masonry of the locks will be 1,302,000 cu. yds., the cut stone 5,700 cu. yds., the brick 20,000 cu. yds., and the cast iron 1,830,000 lbs. It takes a very lively imagination which refers to these locks as flimsy or running into the air without support.

ESTIMATED COST.

The Consulting Board of Engineers estimated the cost of the sea-level canal at $247,000,000, and they estimated the cost of the lock canal at $140,000,000, making a difference of $107,000,000. The Isthmian Canal Commission, for reasons which it seems to the undersigned are well sustained in the report that they make, increase the probable cost of the sea-level canal $25,000,000, or carry it up to $272,000,000. Their increase is based on the fact that in the Culebra division the items of excavation, or excavation above the elevation of plus 10, which is put at 80 cts. a cu. yd., and the excavation for 50 ft. below plus 10, which is put at $1.25 per cu. yd. This excavation below plus 10 is 16,194,302 cu. yds., and 11,439,612 cu. yds. is below and the remainder above the sea level.

The Consulting Board adopted a uniform unit price of $1.25 per cu. yd. for the whole, and this price seems to the Canal Commission fair for the portion above the level of the sea, but it appears that in the calculation of the Consulting Board for rock below sea level from Bohio to Obispo they have charged $2.50 a cu. yd., and for rock below sea level from Pedro Miguel to Miraflores they have also charged $2.50 a cu. yd. All material below sea level in the Culebra Cut is practically rock, and there is no satisfactory reason given anywhere why that should not have the same price of $2.50 as the same material in the other two divisions. This increases the cost in the Culebra Cut, adding, say, 20% for contingencies, to $17,159,418. The Commission also demonstrates that the estimate of $3,500,000 for completing the river diversion, the formation of dams across tributary streams, and the regulation of rivers which flow into the canal, the estimate of the Consulting Board, is too low, and that it should be increased from $3,500,000 by the sum of $7,800,000.

The truth is that the estimate as to the sea-level canal, with reference to the diversions and other construction, is much less definite and much more of an estimate, without sufficient data, than the estimate for the lock canal. The addition of $25,000,000, to make the cost $272,000,000, is by no means an unreasonable increase. This would make the cost of the sea-level canal nearly double the cost of the lock canal; but there is another item that should be taken into consideration, and that is the item involved in the extra time of construction.

Speaking roughly, the time of construction of the canal of either type is practically measured by the excavation that will have to made in either type in the Culebra Cut. There are 110,000,000 cu. yds. to be excavated in that cut for the sea-level canal, and something over 50,000,000 for the lock canal.

TIME REQUIRED FOR BUILDING.

Now, it is calculated that the principal 50,000,000 cu. yds. of the cut can be excavated in about seven years. If this be true, then it certainly follows that the remainder of the excavation which will be also in the cut and will be in rock, a considerable part of it below sea level which must be constantly pumped out, will take more than the first 50,000,000. It is said, however, by the majority of the Consulting Board, that the construction of the Gatun locks, that is, the excavation for the foundation, which will involve an excavation only of some 3,600,000 cu. yds. will take four years, and that the construction of the locks and gates will take more than that. This is not in accord with the estimate of the minority or the Commission, but they allow generously for contingencies eight years and a half to nine years.

The truth is that no allowance is made in this estimate of the time assigned to the construction of the Gatun locks, for the fact that it will be entirely feasible to begin the construction of the lock walls before the whole site of the lock structure has been excavated. The undersigned, in weighing this evidence, therefore considers that the minority are too generous in their concession, but admitting for the purpose of argument that the time would be nine years, certainly if it will cost nine years to construct the lock canal it will cost more than fifteen years to construct the sea-level canal. Fifteen years is the estimate fixed by the minority of the Consulting Board. Indeed, upon a vote as to whether it should be fixed at fifteen years the Consulting Board stood six and six. Chief Engineer Stevens and the Canal Commission think that it will probably take eighteen years, and perhaps twenty, to construct a sea-level canal, and the undersigned concur in that view. But for the purpose of stating the difference in actual cost to the Government between the construction of the lock canal and the sea-level canal, let us assume the time to be nine years for the lock canal and fifteen years for the sea-level.

The probable cost of the sea-level canal is $272,000,000. This would involve an average expenditure of about $18,000,000 a year, and if bonds at 2% were issued to meet this expenditure the simple interest during the fifteen years of construction would amount to $37,800,000. With a lock canal at a cost of $140,000,000 the average expenditure would be, for nine years, $15,555,555, and at 2% for nine years, simple interest, the interest would amount to $11,199,996, or a difference to be added to the cost of the sea-level canal over and above the lock canal of $25,600,000.

But this is not all. Upon the completion of the lock canal at the end of nine years, in 1915, the majority of the Consulting Board assume, from a discussion of the subject by Professor Johnson, contained in the report of the Commission of 1901, that the tonnage of the first year would be about 7,000,000 tons. The tolls of the Suez Canal, which cost much less than the Panama Canal, are now 7 francs a ton, or $1.40. If this were to be reduced to $1 a ton, the gross income from 7,000,000 tons would be $7,000,000. We may assume, for the purposes of the argument, although probably we would be justified in taking a larger figure, that the average tonnage for six years, representing the difference in time from the completion of the lock canal and the completion of a sea-level canal, assuming the lock canal to be constructed and completed in nine years, would bring in a gross income each year of $7,000,000.

COST OF MAINTENANCE.

The minority of the Consulting Board have entered into a consideration of the cost of maintenance of the canal, which the majority of the Board have not considered. They say that the maintenance of the canal would probably amount to $2,500,000. The annual interest charge on the cost of the canal would be $2,800,000. At this rate there would be net earnings of $1,700,000 a year additional for the six years during which a sea-level canal would have been building.

This would make a total of $10,200,000, which, with the difference of $25,600,000 in interest charges, already stated, would make the total difference in cost between the two types on the day the sea-level canal would be open for business of $167,800,000.

In addition to this difference there would, with the sea-level canal, be a delay of six years in the great benefit to be derived by this country in the doubling of the efficiency of its navy by the ability to transfer its vessels from one ocean to the other with great dispatch; and also, and even more important, there would be the delay for this period to the commercial interests of this country and of the world in the enjoyment of this great interoceanic waterway.

The majority of the Consulting Board made no estimate of the difference of maintenance in the two types of the canal. The estimate as to difference in maintenance given by the majority of the committee is based on some statements as loose as similar statements by the same witnesses in respect to the cost of land for the lakes, to which we shall hereafter refer. In addition to this matter of annual maintenance it must be borne in mind that on the difference of $132,000,000 of bonds issued to construct the sea-level canal, leaving out altogether the additional interest which has been paid up to the time of the completion of the sea-level canal, there would be an annual interest charge greater for the sea-level canal than for the lock-level canal of $2,640,000, so that the difference in the matter of maintenance and fixed charges in favor of the lock canal would be more than $2,500,000 a year.

COST OF SUBMERGED LANDS.

One matter with respect to the cost of the lock canal which is mentioned in the report of the majority of the committee ought to be noticed, not only because of its bearing on the cost of the lock canal, but, even more, because it throws light on the looseness of the estimates on which some of the expert witnesses depended for the sea-level canal and, indeed, of the majority of the committee itself is reached. The matter is the estimate of the cost of the lands which will be overflowed by Lake Gatun and Lake Sosa. These lands amount, so far as can be calculated, to about 20,000 acres, of all private ownership, in the Zone, and 17,920 acres of land belonging to the Republic of Panama or to private owners outside of the Zone, or 38,400 acres. This was asserted to be worth, by the minority of the Consulting Board, $7.70 an acre, and $300,000 was included in the cost of the lock canal.

The majority of the committee estimate the cost of this land at $10,000,000, or at $263 an acre; and one witness, Mr. Wallace, estimated its cost at $25,000,000, or $657 an acre; and Mr. Burr at $18,000,000, or at $500 an acre. The estimates of the witnesses and the estimate of the majority of the committee are, with deference, preposterous. They seem to be based on the prices paid for two pieces of land on the rising ground immediately overlooking the Bay of Panama admirably situated for residences or public buildings and selected by the Secretary of War and the Commission, the one for a place in which to erect the Governor's house, and the other the Hotel Tivoli, which is to be the grand hotel of the Isthmus, erected by the Government. The value of these two tracts was fixed by a commission appointed under the Hay-Varilla treaty. The treaty provides that in fixing the value of the land the President of the United States may appoint two of the appraisers and the President of the Republic of Panama the other two, and then if the four can not agree, that the two Presidents shall select a fifth.

The gentlemen representing the United States were gentlemen of high character, having no interest whatever in the controversy except to reach a just conclusion, and were competent and able business men of large means. The undersigned are not acquainted with the character of the Panamanians selected for the commission, but they understand they were also men of good character. The statement that the value put upon these tracts of land by these American gentlemen were two or three or four or five times their true value is utterly without foundation, in the opinion of the undersigned. The truth is that the larger of the two tracts, containing 48 acres, is on the seaside of the lower slope of Ancon Hill, immediately adjoining the city of Panama, and is beautifully situated for suburban residences. It adjoins the Ancon Hospital grounds and is the choicest property on the Isthmus. It was bought as a site for the house of the Governor of the Zone. The owner asked $100,000 for it. The Isthmian Canal Commission offered $55,000 for it, and it was finally submitted to the Board of International Appraisers, heretofore described, and they fixed its value at $41,000, or at the rate of $854 an acre. This property was purchased for about $11,000 in 1888, but an increase of $40,000 under the circumstances was entirely reasonable and legitimate.

It is quite true that the coming of the Americans on to the Isthmus and the construction of the canal has doubtless raised the price of property. Could, however, anything be more absurd than to take this price as a basis for calculating the cost of the land to be taken for the two lakes, Gatun and Sosa? That part of the land which has houses upon it is occupied by tenants under revocable licenses and belongs to the Government. That which is owned by private individuals is remote from the railroad, reached by no roads, and accessible only in high water by canoes. It is a trackless jungle. Doubtless a large part of the 18,000 acres estimated to lie outside of the Zone is owned by the Republic of Panama, and, becoming necessary for canal purposes, is ceded to us under the treaty. More than this, if any such preposterous price as this mentioned is to be assessed for the value of private land covered by Lake Gatun and Lake Sosa, similar prices are quite as likely to be assessed for the lakes formed in the plan of the sea-level canal, Lake Gamboa and the lakes Gigante, Gigantito and Caujo.

It would seem to the undersigned that these estimates are only evidence of a hopeless effort to increase the estimated cost of the lock canal in comparison with the much larger demonstrated cost of the sea-level canal.

We respectfully submit that the bill should not pass.

J. H. Millard.
J. F. Fryden.
A. J. Hopkins.
P. C. Knox.

APPENDIX.

Hon. J. H. Millard,
Chairman Committee on Interoceanic Canals,
United States Senate, Washington, D. C.

My Dear Senator:

When before your Committee I did not bring up the subject of the effect of earthquakes on dams because it seemed to me not of sufficient importance. I had, however, previously given the subject careful consideration in connection with the design of the Gatun Dam.

It is my opinion that a dam so designed is earthquake proof, by reason of the great height to which it is built above the level of the water in the proposed lake and on account of its extremely liberal dimensions in other respects. Any shaking occasioned by an earthquake would tend to consolidate rather than to disrupt such a dam.

If a fault line, or line of rupture, should occur, passing directly through the dam, the pressure of the superincumbent earth would, in my opinion, squeeze the sides of the fissure together so that no water could pass out of the lake.

The high portion of the dam from the water line down, and for a short distance above the water line, is designed to be made chiefly of clay which, in my opinion, as I have already indicated, would squeeze together readily under a weight of 50 ft. of earth, equal to about 2½ tons per sq. ft.; but, if any one questioned the certainty of this action, the weight could be increased, without materially increasing the cost of the canal, by building the high portions of the dam up to 100 or 150 ft. above the water line.

It may be of interest to you to know how the dams which I referred to in my testimony, and which were nearly all in the earthquake district of California, withstood the shock of the earthquake. I am therefore sending you with this a part of this week's Engineering News (May 17, 1906), containing a communication from Charles Derleth, Jr., Associate Professor of Structural Engineering in the University of California, at Berkeley.

With this communication there is a map of the San Francisco Peninsula and surrounding territory, on which has been located what he calls the "fault line," or main line of rupture of the earthquake. I have seen statements from the professors of Stanford University, that they had traced the fault line southerly from where it is shown on this map, and it was a direct continuation of the line shown.

Prof. Derleth says that "the region of maximum earthquake disturbance appears to lie along or near" this fault line. He also says, in speaking of the appearance along this fault line:

> To an eye witness the effect is almost awe inspiring. One can travel for miles along an almost exact right line and find the ground cracked and disturbed as though some giant had run a plow or a knife through it.

I am calling especial attention to this line, because it runs through the region where most of the dams which I referred to are located.

In my testimony I referred to the Pilarcitos Dam, which is shown on the cross-sections of dams accompanying the report of the Board of Consulting Engineers. This dam is constructed wholly of earth and is about two miles west of the fault line. It has the same depth and pressure of water against it as the proposed Gatun Dam and "is unaffected." The reservoir back of it is full of water.

I also called your attention to the San Andreas Dam, which is almost an exact counterpart of the Pilarcitos Dam. The fault line touches the eastern edge of this dam. Prof. Derleth says regarding it:

> As an eye witness I am convinced that this dam was subject to a most severe earthquake shock, and since it retains the water of San Andreas Lake apparently just as well as before the earthquake, it should be a source of great satisfaction to its designer and builder. The ground is considerably scarred by cracks running north northwest on the eastern bank of the dam, where the nose of a hill naturally projects to form its abutment. Those cracks, which are quite pronounced, are in the abutment and not in the dam itself. There are a few smaller cracks running in the same direction at the extreme westerly end of the dam. On the roadway of the dam there are some small longitudinal cracks, apparently due to the unequal settling of the triangular masses with respect to the core, but they are not serious. The writer is convinced that an earth dam properly constructed will stand a very violent shock, and he cannot praise too highly the construction of this one.

A flume, resting upon a wooden trestle of considerable height, which discharged water into the reservoir at the easterly end of the dam, was destroyed.

The fault line south of the San Andreas Dam continued through the middle of the long and narrow Crystal Springs Reservoir, in which the water is retained by a concrete dam 115 ft. high above the natural surface. The reservoir at the time of the earthquake was full. Prof. Derleth, after stating that this dam "was subject to a series of thrusts and pulls in vertical planes along

its length, since it is parallel to the fault line," adds: "So far as the writer could see, and he observed the dam carefully, there is not the slightest crack."

I know of no mass of masonry in the country that is more like the masonry of the proposed locks at Panama than the Crystal Springs Dam. It is located only ¼ mile from the fault line, and has stood the test of the earthquake without being affected.

Other experience at San Francisco also shows that structures which are frail in comparison with those proposed for the canal, have successfully withstood the earthquake shock. I refer to the general experience with steel frame buildings, and with structures in general which have been well built with cement instead of lime mortar.

Prof. Derleth corroborates the statements of others, which I have previously seen. He says:

> The region about Millbrae has been subjected to a very severe shock, but the Millbrae pumping station has been absolutely unharmed by the "temblor." I should observe that it is a practice of the Spring Valley engineers to use cement mortar for their brickwork, with selected brick, and to use careful proportions of cement, sand and stone of the highest qualities for their concrete. The brickwork and concrete of the Millbrae pumping station exhibit no cracks whatever. In striking contrast thereto one may see near the Millbrae station of the Southern Pacific Railroad the power-house for the trolley lines which run cars from Fifth and Market Sts. in San Francisco to San Mateo. This building is of cheap brick construction and has been almost utterly destroyed.

He also says with regard to a smaller pumping station built in a similar manner, located not far from the Valencia Hotel, but on higher ground, that it "was subjected to a very decided shock, but there is not a crack in the brickwork of that pumping station and the brick chimney is entirely intact." It will be recalled that the Valencia Hotel was entirely destroyed by the earthquake.

The San Leandro Dam [Oakland water-works.—Ed.] which I also mentioned in my testimony as the highest earth dam in the world, was not as near the center of activity of the earthquake as the others which I have mentioned. It is, however, located only five miles from the easterly shore of San Francisco Bay and nearly opposite the dams of the San Francisco water-works. I have heard from two sources that this dam was not affected in any way.

It has never seemed to me that at Panama, where as fragile a structure as a church tower has remained intact for centuries, that the effects of an earthquake were to be considered in determining the type of a canal, and the recent experience in San Francisco certainly corroborates this view.

I have just received your letter of the 19th instant, asking me to give you such information as I have regarding the effect of an earthquake upon locks.

I have not seen the report of the majority of your Committee, except as extracts have appeared in the papers. These extracts, referring to the lock walls, stated that they "would, at least some of them, be more than 75 ft. high and entirely unsupported on one side save for a part of the height by water. If these walls had been moved at all, the natural and probable result would be in their leaning and so prevent the closing of the gates," and further stated: "But the most likely effect of such shock would be the fracture of these locks, in repairing in which much time—months or years—might be required."

In considering the effect of an earthquake upon the proposed lock walls at Panama, it is necessary to bear in mind that these walls, with the exception of some of the approach walls or piers, are all to be founded upon rock, and that as planned they are enormous masses of masonry about 54 ft. thick at the base, which would require a very much greater power than the San Francisco earthquake, or any known earthquake at Panama, to disturb them in any way.

The nearest parallel to the lock walls in the earthquake district at San Francisco is the concrete dam at the Crystal Springs Reservoir, which was located only ¼-mile from the main fault line, or line of rupture, of that earthquake. This mass of concrete masonry had an enormous pressure against it on one side, due to water 115 ft. deep, and Prof. Derleth says that he has examined the dam since the earthquake and it is entirely free from cracks. If the dam had leaned as the result of the earthquake, cracks would undoubtedly have been noticed at its ends and there would have been a leakage of water through them.

The other suggestion of the majority that "the most likely effect of such a shock would be the fracture of these locks," while it may be true, in comparison with their other hypothesis relative to the leaning of the walls, is, to my mind fanciful, as the experience with the recent earthquake in California—and I have followed all that has been written carefully—does not show that solid structures resting upon rock were cracked in any case. The whole weight of the evidence, on the other hand, is that well built structures, which are frail in comparison with the lock walls, are entirely free from cracks. There are many instances of this kind which have been published in the engineering papers.

Prof. Derleth, who has already been quoted, calls attention to the fact that the brickwork and concrete of the Millbrae pumping station exhibit no cracks whatever, the work being of a first-class character and built with cement mortar, while an electrical power-house of cheap brick construction near by had been almost entirely destroyed. He gave similar testimony with regard to the brickwork of another pumping station in San Francisco. The pumping engines in these stations are delicate machines which if moved or twisted would be thrown out of alinement so that they would not run, but they were not affected.

After speaking of many other buildings which stood because of their good construction, Prof. Derleth says: "Brick buildings properly constructed with good bond and cement mortar, and resting upon foundations acting as units, can withstand heavy earthquakes." How much more should a solid mass of masonry more than 50 ft. thick resting upon a foundation of rock?

Although it is perhaps unnecessary, I will consider the extent of the injury which would result from an actual occurrence of such mishaps as have been pictured by the majority of your Committee.

In considering the effect of leaning walls it should be remembered that the locks are in duplicate, so that it would be necessary for two walls opposite one another to lean in order to throw both locks out of service. A slight leaning of the walls would throw the gates away from the miter sills and from each other so as to let a moderate amount of water pass through, but temporary repairs could be made in a short time by bolting to the gates and miter sills timbers of proper shape to make the gates tight enough for service. A transverse crack through the concrete walls would not affect the stability of the structure and would only require filling with mortar or masonry to prevent the water from escaping from the locks and conduits. Such repairs could be made in a very short time.

When an argument is made in favor of the sea-level canal, as to the insufficient strength of dams or lock walls, the question which always arises in my mind is, why not make them stronger at an expense of a very few million dollars, rather than to assume that it is necessary to spend an additional $107,000,000, and a large amount for interest, for building a sea-level canal. Similarly, when the argument is made that some repairs may throw the canal out of service for several months, it seems rather absurd to adopt as an alternative, a type of canal which will not be available for use for at least six years longer than the lock canal.

ANNUAL CONVENTION OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS AT MILWAUKEE, WIS.

An annual convention with unusually slim attendance was held by the American Institute of Electrical Engineers at Milwaukee, Wis., last week (Monday, May 28, to Wednesday, May 30). The convention was the twenty-third in the society's history. Only about 200 members and guests were in attendance, and not more than half this number came from points beyond Chicago. Ordinarily, the summer convention, the only general gathering of the Institute, is held late in June, when summer weather and vacation time co-operate in bringing many visitors. This year a projected trip to England, intended in return of the official visits of the British and Italian Societies of Electrical Engineers in 1904, caused the management to shift the convention date to the last week in May. This may have affected the attendance. The weather was distinctly not June weather, and the straw hats affected by some of the Eastern contingent were a little out of place.

The five sessions of the convention were quite busily occupied, in fact, were barely adequate for all the work before the meeting. The first two sessions were held in the auditorium of the new Public Service Building of The Milwaukee Electric Railway & Light Co., an extensive and elaborate building intended to accommodate the offices of the company and containing a car-barn and waiting-rooms in the lower story. The structure is not yet occupied. The last three sessions of the convention were held in a smaller and acoustically more suitable hall in the University Building.

On the evening of the opening day an "informal" reception, tendered the Institute by the local committee, was held at the Hotel Pfister, the headquarters. A planked whitefish dinner at Whitefish Bay, four miles north of the city, on Wednesday evening, was the other social feature of the meeting. It had been planned to hold the concluding session on Thursday morning, and a banquet had been set for the evening of that day. The anxiety of Eastern members to return caused a change of program, however, by which the fifth session was shifted to Wednesday afternoon, and the banquet was omitted.

The many industrial plants of Milwaukee afforded ample opportunity for visiting tours of varied interest. One such tour, to the Allis-Chalmers works at West Allis, was made by the entire party; on Thursday those who remained made individual visits to various plants, of which a large number had hospitably opened their doors.

Professional Proceedings.

The meeting was opened at 11 a. m., Monday, with an address by Retiring President S. S. Wheeler, of Ampere, N. J. The speaker dealt with an unusual theme: Engineering Honor. In substance he made a plea for a code of engineering ethics, a plea supported by citations from the codes of other professions and from principles of professional ethics laid down in writings and addresses of engineers and other professional men. President Wheeler pointed to the fact that electrical engineering is the youngest of the grand divisions of engineering, but that it has now attained to such standing that its American representative organization may with propriety consider the matter of formulating a code of rules of practice which shall forward and regulate the development of the engineering profession as a profession. Professional ethics are more than a matter of convention or dignity. The professional man has direct and clear responsibilities to three parties: the client, the public, and the profession; and a code of ethics is a device for aiding him in keeping these responsibilities, and their contingent duties in mind, and more easily discerning the relations which exist between them.

President Wheeler enlarged somewhat upon these duties, and gave expression to some of the guiding principles of engineering ethics. But he made it clear that he hoped for action by the American Institute of Electrical Engineers to study the matter and, eventually, to establish a code of ethics for the guidance of the profession, at least the electrical branch.

This hope was realized. At a later session of the meeting, Past-President Charles P. Steinmetz, of Schenectady, N. Y., made a motion that the president and the directors of the Institute nominate a committee to consider the advisability of drawing up a code of professional ethics, and, if they consider the step advisable, to proceed with the formulation of such a code, this code in its first draft to be submitted to the society for criticism, and after later revision to be re-submitted for adoption. Prof. D. C. Jackson, of Madison, Wis., seconded the motion. Past-President C. F. Scott, of Pittsburg, Pa., spoke briefly in support, and the motion was then carried unanimously.

STANDARDIZATION RULES.

The revised Standardization Rules for electrical apparatus were submitted to the convention by the Committee on Standardization, for discussion or adoption. Mr. Charles F. Scott (Pittsburg, Pa.), who presented the report, stated that the committee, after completing its task, felt that the revised code should be rearranged, for greater clearness and convenience; but time had not been available before the convention to undertake this work. He asked, on the part of the committee, that the revised rules be referred back to the committee for rearrangement, and that they be then submitted to the board of directors and published upon approval by that body.

It immediately developed, however, that individual members of the Institute believed the rules to be much less perfect than did the committee. Numerous criticisms of the rules were made. Mr. A. W. Berresford (Milwaukee, Wis.) pointed to the paragraphs dealing with rheostats, and characterized it as wholly out of accord with commercial practice. The paragraph fixes the limiting temperature-rise of any rheostat, at the external surface, at 75° C. above air temperature, whereas rheostats as made and sold to-day frequently show a rise of 130° to 150° C.

at the external surface, and these temperatures involve no disadvantage or injury. Mr. Berresford criticized similarly nearly every other clause of the paragraph. Mr. N. J. Neall (Boston, Mass.) made objection to the section on rheostats and the section on lightning arresters. Mr. F. A. C. Perrine objected to the phraseology of the clause governing temperature-rise, as not being clear. Numerous others made objection to specific parts of the code. Prof. D. C. Jackson (Madison, Wis.) entered a wholesale protest against the rules, as being greatly excessive in scope, aiming to define and limit matters which should not be hampered by rules, and including much matter properly belonging to text-books rather than to a code of standards. Mr. C. P. Steinmetz, member of the committee, explained that the intention had been to secure approval of only the general form of the rules, and that adoption of the specific details was not asked. He moved that the rules be referred back to the committee, the latter to invite and consider criticisms from the members of the Institute within a period of six weeks after the convention, and then to submit the code to the board of directors for approval and publication. Prof. D. C. Jackson moved to amend so as to require a vote of the Institute membership to approve the rules; but the amendment was lost. The original motion of Mr. Steinmetz was then carried.

A report was made to the convention by the Committee on Local Organization, Mr. C. F. Scott, chairman. The view was expressed that the local branches of the Institute have now become a permanent factor of value in the life of the organization, that the past three years of local branch administration had been based on tentative plans and principles, and that it is now time to initiate a more advanced scheme of management. No definite recommendations were made. Major G. O. Squier (Fort Leavenworth, Kans.), formerly active in the San Francisco branch, and Mr. K. B. Miller (Chicago, Ill.), of the Chicago branch, gave some views of local branch work from the inside.

While the discussion was interesting in its bearing on local branch administration, it led to no action, and the subject was dropped.

ELECTRIC MACHINES.

The program of professional papers was opened with a paper on "A Repulsion-Induction Motor," by Mr. M. Milch (Schenectady, N. Y.). The motor described is a single-phase machine which affords a combination of the starting characteristics possessed by the repulsion motor with induction-motor characteristics at higher speeds. The repulsion motor has a high starting torque without drawing an excessive starting current from the line; its subsequent speed-torque relations are similar to those of the direct-current series motor, that is, the torque (and current) falls off as the speed increases. The no-load speed is therefore very high. On the other hand, the induction motor tends to maintain a constant speed at all loads. A single-phase induction motor is unable to start itself, though by auxiliary devices it may be made to start if unloaded. Once started it tends to run at a speed synchronous with the rotating magnetic field produced by the alternations of the current supply; at full load the motor speed will be only a few per cent. below synchronism.

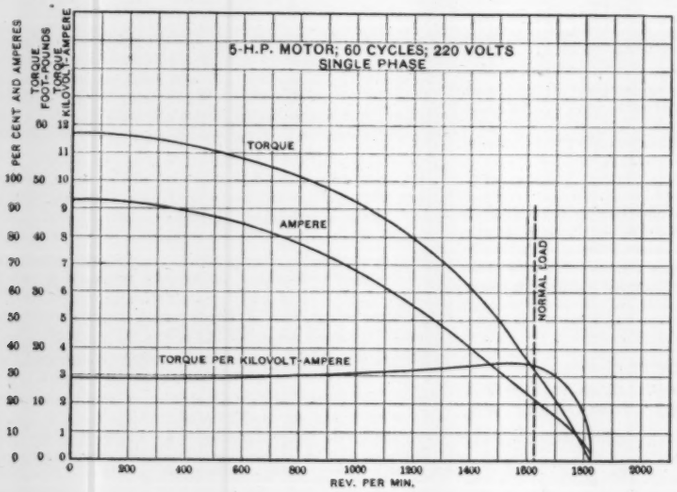
The motor described by the author, which was developed at the works of the General Electric Co., has a torque which is high at starting, and decreases with rising speed, reaching zero at a speed somewhat above synchronism. The torque per kilovolt-ampere remains approximately constant up to a point near the limiting speed, when it rapidly drops to zero. As the load on the motor is increased, the speed falls off considerably more than in a pure induction motor; in a 5-HP. 60-cycle 220-volt motor which was built and tested the speed dropped 12½% between no load and full load. The characteristics of this motor with respect to increasing speed and increasing load are shown in Figs. 1 and 2 herewith, taken from the paper. The performance of the motor is comparable with that of a compounded shunt motor (direct current).

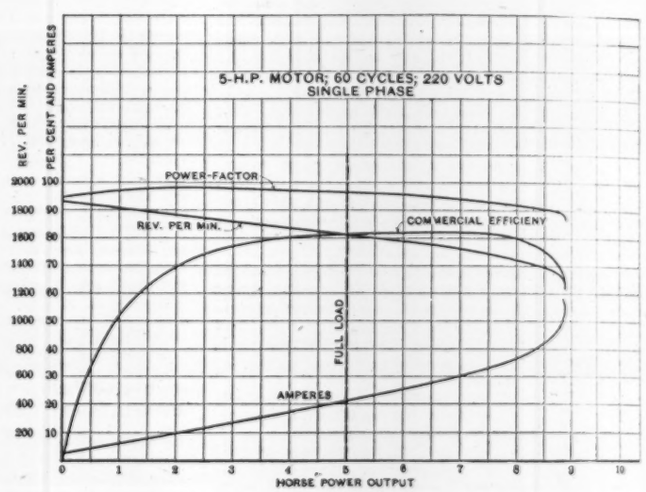
The motor has distributed windings on rotor and stator, and two sets of short-circuited brushes set nearly at 90° to each other. It is a direct combination of a commutator induction motor with a repulsion motor, employing the same windings for both; the current is sent through the stationary windings as in these types of motor, and an additional voltage is impressed on the induction-motor circuit of the rotor, through a suitable impedance. An analysis of the operation of the motor is given in the paper.

The paper was discussed briefly by Prof. D. C. Jackson (Madison, Wis.), Mr. G. P. Cole (St. Louis, Mo.), and Mr. C. P. Steinmetz (Schenectady, N. Y.). Prof. Jackson advanced the opinion that polyphase induction motors are not suitable for general power purposes in small units, which latter will always be of wider interest than large units of power utilization. Single-phase power distribution is the ideal method, and on this account a self-starting single-phase motor is highly valuable. He expects a great advance within the next decade in this field of electric work.

The second paper read, "Comparison of Two and Three-Phase Motors," by Mr. B. T. McCormick (Cincinnati, O.), gave an analysis of the comparative effects in using a given motor frame with two-phase and three-phase windings respectively. The conclusions of the author are distinctly unfavorable to the two-phase motor, which he finds has 12% higher copper loss, requires 22% more conductors per slot, slightly lower efficiency, 20% greater slip, and somewhat lower power-factor than a three-p[hase] motor. Mr. C. P. Steinmetz (Schenectady, N. [Y.], in discussing the paper, considered these [conclusions] too radical, and believes that the [two]-phase motor is not as inferior as the autho[r] [concludes].

Two further papers on alternating-[current] machines were read at later sessions, na[mely], "Heat Tests on Alternators," by Mr. S. Se[ller] (Cincinnati, O.), and "The Self-Synch[ronizing] of Alternators," by Prof. Morgan Broo[ks] and Mr. M. K. Akers (Urbana, Ill.). The form[er] described a number of arrangements for maki[ng] artificial full-load tests on large alternators, [where] the power required to make a true test [is] impracticably large. Present methods for t[his] purpose, of which there are several, require [either] two identical machines to be tested simultaneously, using one as generator and the other as motor, or they are applicable only to alternators having at least eight poles. The methods shown in the paper are intended to get around these limitations. It was pointed out in discussion by Mr. C. P. Steinmetz, that the problem of testing large alternators is not wholly solved by devising test-connections which will give full-load current in the short-circuited armature with full-load





FIGS. 1 AND 2. STARTING AND RUNNING CHARACTERISTICS OF 5-HP. REPULSION-INDUCTION MOTOR (M. MILCH).

excitation of the fields, but that a formidable difficulty remains, namely, the variation of air-temperature during the twelve or twenty-four hours or more required by large machines to reach a steady running temperature. Neither the terminal nor the final air-temperature of the test, nor any easily determined intermediate temperature, can be taken as the mean. Ideally, the test run should be continued for several weeks, and, rejecting the period of warming up, say the first day, the average of the remainder would give a reliable value for temperature-rise in the machine. It appears that in making acceptance tests of a 1,500-KW. alternator at Milwaukee, this difficulty was surmounted by boxing-in the alternator and supplying air at constant temperature to the inside of the box.

The paper of Prof. Brooks and Mr. Akers described the results of experiments intended to show how, in paralleling alternators, the machines may be caused to draw each other into synchronism and proper phase relation, without exchanging injuriously heavy circulating currents, even when thrown into parallel at a considerable phase difference. The desired effect is secured, they find, if an air-core inductance of suitable value is contained in the parallel connection. By choosing an inductance of such value that the momentary current interchange under the worst conditions does not exceed half the full-load current of one machine, enough synchronizing force remains to bring the machines into step quite positively. The method may be applied to rotary converters, but when these are started on the direct-current side an additional inductance should be placed in the

direct-current leads, in order to prevent possible tendency to race due to field weakening in synchronizing. The authors also predict that their method may be used to great advantage in synchronizing frequency-changing motor-generator sets, which require to be synchronized on two circuits simultaneously. In this case it is recommended that the extra inductance be chosen of such size as to leave a synchronizing force insufficient to force the machines into step unless both circuits are simultaneously in synchronism. The paper received no discussion.

Mr. W. L. Waters (Milwaukee, Wis.), in a paper entitled "Shunt and Compound-wound Synchronous Converters for Railway Work," presented a strong argument in favor of using shunt converters in railway sub-stations, except in a relatively small class of special cases. The compound machine costs 7 to 8% more than the shunt, and requires auxiliary reactance coils and switchboard equipment which will double this excess. The efficiency of the system is lowered 1 to 2%. The regulation of voltage which the compounding is intended to secure is illusive with rapidly fluctuating load, as the field magnetism of the converter cannot change rapidly enough to follow the load changes. The added complication of the compounded equipment gives added chance for trouble in operating. The author concedes that compound converters are at present the popular type for railway sub-stations but he also says that in not a few cases the operating engineers later cut out the series field coils and the auxiliary reactance coils, and run their converters as straight series machines.

Mr. J. B. Taylor (Schenectady, N. Y.) and Mr. P. M. Lincoln (Pittsburg, Pa.) took issue with the author. Mr. Taylor pointed out that the voltage drop on the trolley wire is sufficient to give proper division of load between adjacent stations, and the feeder drop may therefore be compounded profitably. In large cities shunt converters may be adequate, but in all other traction systems the compound winding of converters is valuable as a simple automatic means of keeping up the voltage at the load peaks. Mr. Lincoln, agreeing generally with this view, noted that the Manhattan (elevated) Ry. in New York has recently changed all its rotaries from shunt to compound, indicating that even in heavy-traffic city systems the compound converter may be found preferable.

The last paper concerned directly with electric machines was "Direct-current Motor Design as influenced by the use of the Inter-pole," by Mr. C. H. Bedell (Bayonne, N. J.). Commutating poles, intermediate between the main field poles and carrying a series winding so as to always neutralize the armature reaction and leave a concentrated residual field over the coils short-circuited by the brushes, sufficient to prevent sparking, were first used almost twenty years ago. They never came into regular use, and soon were almost forgotten. In recent years, however, special requirements upon direct-current machinery have appeared, which brought about a return to the "inter-pole" and which have made this discarded device remarkably popular. The first of these new requirements was imposed by the demand for motors to drive machine tools, where a large range of speed at full output of power was called for. Shunt motors of ordinary type do not permit of a large speed-range under these conditions, and even a moderate range is obtained only at the cost of extra size and cost or else reduced output. The inter-pole here finds its value in giving a much larger range of speed by field regulation alone (without the provision of several different voltages for the armature), and actually reduces the size and weight of motor required for a given service. The other new requirement is imposed by the need of high-speed generators for direct connection to steam turbines, where commutation difficulties are aggravated; the inter-pole has been used with success in the design of such machines. The author, who played a leading part in the re-crudescence of the commutating pole, takes occasion in this paper to show that in many elements of the design of direct-current motors, where past practice established certain limits of normal design, these limits are greatly shifted when commutating poles are used, and that a recognition of the changed limits enables the design to be cheapened and improved.

In discussion, Mr. H. F. T. Erben (Schenectady, N. Y.) remarked that commutating poles were tried 14 or 15 years ago on a 500-KW. dynamo built by the General Electric Co. The results of the trial were not very favorable, and no further work was done. He recognizes now that the commutating poles in that trial had too small an exciting winding for proper results. During the past year or two the device has been tried on all sizes of machines, up to 2,000 KW., and has been found a very great boon to the designer of generators and motors. On high-speed steam-turbine generators the inter-pole gives practically perfect commutation. Machines of very heavy amperage have been built with inter-poles, and work excellently. By shifting the brushes slightly from the neutral point, generators may be slightly over-compounded to run in parallel, without compound winding on the main poles. It is found that the inter-pole flux is closely proportional to the armature current, that is, the inter-pole works on a straight-line magnetization curve. The core-losses of inter-pole machines are low, without distributed pole-face winding. The inter-pole has been adopted by the General Electric Co. as standard for all its steam-turbine dynamos. Mr. W. L. Waters (Milwaukee, Wis.) noted that commercial requirements of past years were such that the inter-pole was not necessary for successful design. He credits the multiple-voltage system with having created the demand for variable-speed motor drive which brought back the inter-pole. In high-speed direct-current generators the inter-pole is essential. This applies to motor-generator sets as well as to turbine-driven dynamos. Motor-generators have doubled in speed in the last 18 months, and the likelihood is that this tendency will continue for some time to come. He believes that the advance of direct-current design in the next few years will base mainly on the inter-pole. Mr. David Hall (Cincinnati, O.) remarked that the inter-pole is of no advantage, in constant speed work, as long as normal construction can reduce sparking to such a point that the limiting factor in design is heating rather than sparking. Mr. C. P. Steinmetz (Schenectady, N. Y.) stated that some years ago he tried the inter-pole on the single-phase series motor; commutation was improved, but the gain was more than lost in the decrease of power factor. In other forms of motor, he believes, it will be a question of engineering experience whether the duplication of field coils and poles, the increased pole space, etc., required by inter-pole construction are more than made up by the gain in other respects. In past years he had repeated occasion to examine and report on the inter-pole, and in each case reported against it. Conditions now have changed enough to require a fresh judgment. The case is parallel to that of the unipolar dynamo and the single-phase railway motor. The unipolar dynamo had to wait for a high-speed, large-power prime mover before it could be commercially valuable, and this finally appeared in the steam-turbine; similarly the single-phase series railway motor, known for many years, was not a commercial possibility until the demands of service and improved design allowed it to compete with the direct-current motor on more even terms. The inter-pole had no use so long as direct-current design was limited by heating. Better ventilation and higher inherent efficiency have in recent years raised this limit, and made the sparking difficulty more prominent. Further, if the inter-pole is used, machines may be completely redesigned, with high armature reaction, deep slots, etc. The adoption of laminated field-poles for better efficiency removes the objection to low air-gap in open-slot machines. With these factors, the previously-mentioned demand for variable-speed motors and high-speed generators also acted in the same direction. Under the manufacturing conditions of past years, the inter-pole made machines much more expensive, but on account of the changes noted this is no longer the case. Mr. S. S. Wheeler (Ampere, N. J.) spoke a word for the multiple-voltage system of varying motor speed. While machine-tool builders oppose this system, that is no final argument, as they equally opposed the use of motor drive of any kind, some years ago. Where variable-speed tools are set close together, the four wires of the multiple-voltage system should not be found troublesome to provide for, and the system should prove cheaper and better than the inter-pole system; where the variable-speed tools are scattered, however, the use of inter-pole motors will probably have the advantage. In closing the discussion, Mr. Bedell stated that ventilation is not made more difficult by the inter-pole, as the latter is only about half as long as the armature core. As concerns the utility of the inter-pole in railway motors, he stated that the inter-pole will make it possible to get a speed-range, without loss of efficiency, between the two economical speeds of the ordinary direct-current equipment, by using field regulation. To show the possibilities in this direction, a regular inter-pole motor made by his company was run at 100% overload with field current only 9% of normal, without any sparking.

LIGHTNING PROTECTION OF ELECTRIC TRANSMISSION SYSTEMS.

Three papers dealing with lightning effects and lightning protection in electric transmission systems were read at the third session of the meeting, nearly the whole session being devoted to these papers and their discussion.

A paper entitled "Some Experiences with Lightning and Static Strains on a 33,000-volt Transmission System" was presented by Mr. Farley Osgood (New Milford, Conn.). The line extends from a point near New Milford easterly 30 miles to Waterbury and 26 miles further to New Britain, Conn., crossing the valleys and ridges over most of its course. In 1904 the lightning arresters in use were multi-gap arresters with series resistance; the power station had 64 gaps and 8,000 ohms resistance between each line and ground, and 128 gaps and 16,000 ohms between lines through ground, and the sub-stations had a similar equipment with the addition of a multiplex connection of resistances between phases, which at different times was varied from 750 to 2,000 ohms between each pair of lines. There were 19 lightning storms during the season, which caused 56 interruptions to service. The sub-station equipments were affected the most seriously, the resistance-sticks of the arresters being frequently broken by the discharges. Discharges across the insulators of the power station bus-bars appeared several times, but this was later avoided by placing reactance coils between the arresters and the bus-bars. In the following season the arresters with series resistance were replaced by multi-gap arresters without series resistance, having 672 gaps between line and line, and the same number from line to ground. Reactance coils were placed in all substations to protect bus-bars and machines. The first severe storm of the season destroyed several poles, but no arresters or machines were damaged. Six weeks later an unusually severe storm discharged across the power station arresters and caused an arc that destroyed every gap, welding the gap-cylinders together; the substation arresters also discharged, but were not injured. Six poles on the line were splintered, which led to placing an arrester equipment on the line at its point of highest altitude, 10 miles from the power station; since this installation no poles have been shattered. The 1905 season had only 4 lightning storms, which produced 7 interruptions of service. The author concludes that the showing of the two years demonstrates that the arresters without series resistance are superior to those having resistance in series with the gaps. In the current year the arresters are being operated with a resistance shunted around a portion of the gaps of each bank; this is expected to bring further improved results. None of the lightning storms recounted in the paper caused any

damage to machines, even when the arresters were short-circuited and destroyed by arcing across all gaps in the wake of a lightning discharge. A direct short-circuit in the system, however, caused by a steel rod thrown across the line, short-circuiting two phases, burned out two 550-KW. transformers, punctured the insulation of a 330-KW. transformer in another substation, and damaged an instrument transformer in the third substation.

A lengthy paper on "Methods of Testing Protective Apparatus" was presented by Prof. E. E. F. Creighton (Schenectady, N. Y.), which, unfortunately, is of such detail that it cannot be summarized here.

Under the title "Protective Apparatus for Lightning and Static Strains," Mr. H. C. Wirt (Schenectady, N. Y.) presented a collection of experience and opinions on various elements of lightning-protection apparatus. Briefly, the following views are included: Series resistance is disadvantageous in lightning arresters, or at least is inferior to resistance shunted around part of the gaps of a multi-gap arrester; in a three-phase line with ungrounded neutral, a ground on one line may, when a discharge takes place or a switch is opened, raise the other lines to double their working voltage; a discharge will cross a much greater gap in the form of many short gaps in series than in a single gap; good non-arcing alloys allow a reduction of 5 to 10% in number of gaps as against brass; reactive coils between arresters and machines are not always effective, particularly against low-frequency effects, and in particular are injurious in relation to high-potential strains originating on the machine side, as they prevent these from freely reaching the arresters; an overhead grounded wire on the pole-line seems to be effective in protecting the line, but is not sufficient to protect the machines; line lightning-arresters at specially exposed points appear to be of value in relieving abnormal localized pressures on the line; lightning storms often create high voltages between phases, so that arresters should be designed not only to relieve the potential against earth but also to limit the voltage between wires; multi-gap arresters appear to break line discharges on the zero point of the current wave, as shown by oscillograph records.

The discussion which ensued was exceptionally ample, and on this account only fragmentary reference to it can be made. Mr. C. P. Steinmetz opened with a strong plea for scientific method in locating transmission lines, in place of the current practice of running as near as may be in a straight line between objective points; danger points as regards lightning should be carefully sought out and avoided, and lightning troubles thus avoided to great extent before the right-of-way is purchased. For further protection of the line, he believes in the grounded parallel wire, at one side or preferably over the wires, frequently grounded. This shield wire should not be random telegraph or fence wire, but a substantial steel cable, preferably drawn at higher tension than the line wires. Three such cables are better than one. The money invested in such protection would be a very profitable expenditure. At the most dangerous points, short-circuited loops of wire near and alongside the transmission line will be of further value; the frequency of striking of such loops proves their value. All lightning effects cannot be avoided by these means, though the wave in the line caused by a direct flash will be more rapidly flattened out if the poles carry a shield-wire. Station protection must be used against the remaining effects. Prof. Creighton's work, done jointly by Union College and the General Electric Co., is of special interest in showing a time-element in insulation and gap resistance; a steep wave may not jump a gap, while a flatter wave of lower maximum will do so. There is a frequency effect in the multi-gap arrester which is explained when the device is viewed as a succession of inductances and capacities in series, shunted by capacities. For alternating current, the potential drop in such a combination is a curve, with steepest slope at the line-end. The breakdown voltage therefore becomes lower as the frequency increases. Analogous action may serve to explain the discharge of lightning across gaps a mile or more in length, the raindrops constituting the gap-balls.

Mr. P. H. Thomas (New York, N. Y.) offered an explanation of the failure of series resistance lightning arresters on the New Milford system, namely, that the resistances were too large, 8,000 ohms in the ground connection; moreover, the arresters were of brass, and not of proved non-arcing character. Concerning laboratory tests, he would rule out all tests at extremely high frequency such as advocated by Prof. Creighton; he believes such frequencies would rarely or never occur in practice, and in any case would have very small power. Prof. Creighton in reply cited the fact that high-frequency sparks in the tests had jumped 12-in. needle gaps and punctured ½-in. pressboard, as evidence of the possible damage of such frequencies. Most circuits, he states, have normal frequencies exceeding 100,000 cycles per second, and may easily vibrate in segments to give higher frequencies. Mr. F. A. C. Perrine (New York, N. Y.) noted that the overhead grounded shield-wire, first advocated by Mr. Steinmetz, has come to be appreciated by engineers. The value of choke-coils between arresters and machines has also not been recognized in the past but is coming to proper appreciation. The explanation of Mr. Steinmetz for the frequency effect of multi-gap arresters is supported by the appearance of discharges across such arresters, where frequently a spark starting at the line end dies out in intensity as it nears the ground end, or disappears when only halfway through the arrester. Mr. C. F. Scott (Pittsburg, Pa.), speaking on the proposal to locate transmission lines with avoidance of lightning danger points, remarked that the points of danger are not so certain that they can be recognized and avoided; in one part of the country the main trouble may be at or near the summits of hills and ridges, while in another region the main trouble may be in the valleys, as in the far West. He recalled that the value of shunt resistance in lightning arresters was first discovered by H. N. Potter shortly after the discovery of non-arcing metal by A. J. Wurts, in putting a voltmeter across part of a multi-gap non-arcing arrester, whereby further discharge was suppressed. The idea was first used in large switches for 5,000-KW. generators at Niagara, to miminize arcing.

The papers were also discussed by Messrs. J. B. Taylor, N. J. Neall, P. M. Lincoln and F. Osgood.

A paper on "Magnetic Properties of Electrolytic Iron" was presented by Prof. C. F. Burgess and Mr. A. H. Taylor (Madison, Wis.). Magnetization curves of electrolytically-deposited iron were shown, first, for the iron as deposited, and second, for similar material after heating to 1200° C. for 8 hrs. in magnesium oxide. The former gave a curve like hard steel, while the latter gave a curve like a rather soft steel. The paper was discussed by Messrs. E. F. Northrup, C. F. Scott, W. L. Emmet, C. P. Steinmetz, and Prof. D. C. Jackson. Mr. Emmet suggested that, to show the technical value of the electrolytic iron, magnetic tests should be made on samples which have been forged or otherwise subjected to mechanical working. Mr. Scott mentioned that hysteresis losses consume probably millions of dollars each year, and expressed the hope that the work on electrolytic iron may show a way to reduce these losses. Mr. Steinmetz referred to the recent discovery of magnetic alloys containing only non-magnetic constituents, and remarked that an entire change in ideas concerning magnetism would result therefrom. The average atomic weight of the magnetic Cu-Mn-Al alloy is about the same as that of iron. He finds that a mixture of powdered antimony and manganese acts like iron filings in tracing out the lines of force of a magnet. Antimony melted in presence of manganese becomes magnetic, even with only minute traces of the latter. Zinc and sodium alloyed with manganese are magnetic, as is also a tin-manganese alloy produced by thermite. If the effect of manganese in these a[illegible] would hold in the same ratio for pure [illegible] ganese it would have a permeability several [illegible] as great as that of soft iron. Prof. Burgess [illegible] ported that one of his assistants found a [illegible] pound of manganese and boron, produced in [illegible] electric furnace, to be strongly magnetic.

In a paper entitled "Measurement of [illegible] perature by Electrical Means," Mr. E. F. N[illegible] rup (Philadelphia, Pa.) described instruments [illegible] methods of connection for measuring tem[illegible] tures by the change in resistance of a me[illegible] wire. Some novel forms of instrument [illegible] shown, both "thermometers," that is, the de[illegible] containing the resistance wire, and galvanom[illegible] for reading the resistances. The paper ca[illegible] be abstracted here. There was no discussion.

An electric test-car, for making running tests on electric railways, owned by the University of Illinois, was described by Mr. T. M. Gardner in a paper entitled "Interurban Test-Car of the University of Illinois." The car is a regular 8-wheel interurban car, equipped with four motors, air brakes, and the accessory equipment of an electric car, and further with electrical indicating and recording instruments, a speed and acceleration recorder, a storage battery, and similar equipment for conducting tests of the car. It is intended to add shortly a set of autographic electrical instruments, curve and grade recorders, and diaphragms for measuring air resistance. The discussion of the paper was brief and of minor interest.

Under the title "Economies Derivable From the Use of Relatively Small Water-Powers of Low Head in the Middle West," Prof. D. C. Jackson described the present plant of the electric light company of Janesville, Wis. The system embraces three low-head water-power installations, one of which is used for peak-load service only, and a steam reserve plant. The interest of the paper resides wholly in the detail narrative of the evolution of the plant, which space forbids reproducing here.

A paper on "Some Fundamental Characteristics of Mercury Vapor Apparatus," by Mr. P. H. Thomas (New York, N. Y.), presented a large amount of information on mercury-vapor lamps and converters, in collected but rather heterogeneously arranged form. The first portion of the paper describes the running resistance of a mercury-vapor tube as composed of three parts, the positive electrode loss, the loss in the vapor, and the negative electrode loss, each being called a voltage loss rather than a resistance. An attempt is made to give a physical explanation of these losses. The principally used methods of starting are briefly described. A certain instability at the negative electrode, that is to say, a very abrupt and momentary increase of resistance at the negative electrode, is described, with the statement that the effect is inaugurated in as short a time, probably, as 0.00001 sec. An air-core choke coil, called sustaining coil, in the circuit close to the lamp overcomes this. Connections for alternating-current lamps of the Hewitt type are also shown. Mercury-vapor converters, methods of starting, and means for paralleling them, are described. Special mention is made of the possibility of running such converters in series for supplying series arc circuits. The term "convertion ratio" as applicable to such converters is discussed. Finally, an explanation of short-circuiting in converters and its means of prevention is attempted.

The paper contains the statement that there is no single or rational way to measure the candle-power of a mercury-vapor lamp, on account of the shape of the lamp, the color of its light, etc. This was traversed by Mr. C. P. Steinmetz, who holds that it is always possible to measure the total flux of light, though the procedure may not be quite simple. He finds that a paraffine block photometer allows very close comparison of a mercury-vapor lamp with an incandescent lamp; even the luminometer may be used, with error not exceeding 2 to 3%. His tests show that a 160-watt mercury-vapor lamp (120 watts in lamp) gives slightly more

(Concluded on page 635.)

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If the doctors of the engineering profession disagreed on the type of canal to be preferred at Panama, study of the subject by the Senate Committee has produced still greater disagreement. The members of the Senate Committee on Interoceanic Canals, which has been diligently investigating the whole canal question for the past five months, has now made three separate reports to the Senate. Messrs. Kittredge, Platt, Taliaferro, Simmons and Ankeny, in a report published in our issue of May 24, favor a sea-level canal. Chairman Millard and Senators Knox, Dryden and Hopkins in a report printed in this issue favor the lock canal planned by the minority members of the Consulting Board and approved by the President and the Canal Commission. Senators Morgan and Carmack join in a report favoring a lock canal with a sea-level section at each end carried clear up to the Culebra cut, water supply for the summit level and control of the Chagres being provided for by a dam at Gamboa. This last plan involves, it will be seen, as much lockage as the other; and the sea-level sections at each end will involve as great cost and as many objections as pertain to the complete sea-level plan. Practically the only argument made by Messrs. Morgan and Carmack in support of their project is that the locks and dam would then be founded on harder rock than would the structures at Gatun and Sosa planned by the Consulting Board. This plan is practically unsupported by any engineering testimony and is unlikely to receive any attention from the Senate.

Meanwhile the bill for the sea-level plan offered by Senator Kittredge has been made the unfinished business in the Senate, and action on it may be taken at any time.

To fortify the sea-level side, Senator Kittredge has secured a letter from Mr. C. Henry Hunter, of the Consulting Board, Chief Engineer of the Manchester Ship Canal. Mr. Hunter's main argument is a repetition of that already brought forward relating to the possibility of accidents in a lock canal through a vessel colliding with the lock gates, but recites the experience on the Manchester Canal in somewhat more detail than it has been heretofore given. We therefore print this part of Mr. Hunter's letter as follows:

Of such accidents I have had personal and painful experience, and submit for the information of the committee, the following list of certain of the more serious examples thereof, premising the list by stating (a) that the Manchester Ship Canal was opened for traffic in 1894; (b) that there are on that canal four groups of lift locks (as distinguished from the tidal locks at the junction of the canal with the estuary of the Mersey), with two locks in each group, the dimensions of one lock being 600 ft. by 65 ft., and of the other 350 ft. by 45 ft., and (c) that the respective lifts of the locks vary from 13 to 16 ft., the depth of water on the sill of each lock being 28 ft. The maximum depth of water against any one pair of gates is therefore 44 ft.

List of Accidents to Lock Gates on the Manchester Ship Canal.

Date.	Name and tonnage (gross) of steamer.	Name and size of lock.	Result of collision.
April, 1895	Harold, 682 tons	Latchford, 65 ft.	Intermediate gates destroyed and carried away.
November, 1899	Starlight, 1,481 tons	Barton, 65 ft.	Lower gates destroyed and carried away.
December, 1902	Winkfield, 4,009 tons	Barton, 65 ft.	Do.
June, 1904	Taunton, 366 tons	Latchford, 45 ft.	Intermediate gates destroyed and carried away.
January, 1906	Barbro, 779 tons	Mode wheel, 45 ft.	Lower gates wrecked.

In each of the cases in this list, except the first, where the collision was due to mismanagement, the accident arose from a cause which it is impossible to guard against—that is to say, from the fallibility of the human organism as a working mechanism—as the engineer in charge of the engine room being ordered from the bridge by telegraph to go astern with his engines, went ahead, and in two of the cases where the order was emphatically repeated "full speed astern," repeated his error with equal emphasis and went full speed ahead.

The results which followed the accidents to the lock gates on the Manchester Ship Canal were unfortunate enough, but happily in each case the disaster which impended was averted, as the men in charge of the lock, recognizing the danger, displayed much presence of mind and acted with such great promptitude that they succeeded in partially closing the upper gates of the lock before the rush of water which followed the wreckage of the lower gates took place. In this connection, however, it is, I submit, worthy of the committee's attention that the resulting damage in the cases in which the gates of the 65-ft. locks were wrecked was out of all proportion to that which accrued in the cases of the gates of the 45-ft. locks. In the 65-ft. locks the gates struck were not only wrecked, they were carried clean away, while the upper gates were hopelessly damaged and in two of the cases rendered absolutely unworkable. In the 45-ft. locks the gates struck were wrecked, but were only carried away in one case, while the upper gates received little or no damage and continued to be worked as usual.

The inference to be drawn from this fact is that in the event of the gates of any lock being suddenly wrecked the resultant damage will not only be greater in the case of a larger lock than in a smaller one, but will be much greater in proportion than the actual ratio between the respective dimensions of the two locks.

We invite especial attention to the last paragraph of the above quotation. Mr. Hunter concludes that because in these five accidents, occurring in the course of twelve years, the 45-ft. gates suffered worse than the 65-ft. gates, therefore large lock gates in any such accidents will have much greater resultant damage than gates of smaller size.

We submit that this is drawing a conclusion on extremely slim grounds. It must be evident to any one that the resultant damage in any case will depend chiefly on the weight and speed of the vessel colliding with the gates; and until this variable factor is eliminated there is no means of determining whether large gates are any more liable to damage than smaller gates. This, however, is a minor matter. We call attention to it here only to show that Mr. Hunter appears to be arguing as a partisan of the sea-level canal rather than as an unbiased expert; and we may add that this is further shown by his remark, apropos of the proposal to use an extra set of guard gates at the ends of the lock as a preventive of collisions with lock gates; "The probability is that the result would be that not only two pairs of gates would be wrecked instead of one, but the vessel herself would be sunk in the lock."

The important question, however, is how much weight should we assign to these accidents in the Manchester Canal in fixing on the type of canal for Panama? We have no wish to underestimate the importance of the Manchester Canal experience and the results there ought certainly to be given fair and candid consideration. On the other hand, let us not fall into the error of exaggerating the importance of these accidents. We should consider the experience at the Sault Canal as well as at Manchester, particularly in view of the fact that the Sault locks have passed traffic for nearly half a century and the volume moved both in tonnage and in average size of vessels is very many times that at Manchester.

Probably one reason for the greater number of accidents at Manchester is that the locks are much smaller and shorter, leaving much less leeway in which to stop a vessel after it is fully inside the lock and before reaching dangerous proximity to the gates at the farther end. In the Panama locks, 1,000 ft. long in the clear, there will be much more leeway in which to stop a vessel than in a lock 400 ft. shorter, like those on the Manchester Canal.

Mr. Hunter thinks the use of guard gates would be of no avail, but he gives no reasons whatever in support of his opinion, and it ought to be clear to even a layman that the provision of a substantial barrier which must be broken through before the last pair of gates is reached is a very important safeguard.

Suppose, however, for the sake of argument, that there *is* substantial and considerable danger, as Mr. Hunter avers, in the movement of vessels in a lock under their own steam. Would that be a good and sufficient reason why we should discard the lock plan for the canal, with all its admitted great advantages, and dive down into our pockets for the hundred million odd dollars extra that the sea-level canal will cost? Would not the more sensible course be to see how we can obviate the danger or reduce it to a negligible quantity?

Mr. Hunter claims with much plausibility that there is always a possible chance that the engineer down in the hold of a vessel may err in interpreting the instruction from the bridge and drive his engines ahead instead of reversing them, thus bringing the vessel into collision with the gates. If this is really an important danger to the integrity of the locks, it would be entirely practicable to forbid the movement of vessels by their own power from one end of the locks to the other. Special tugs for moving the vessels could be provided by the canal management on which the engine room and its operating levers could be placed on deck where the engineer could see just where he was moving, and be in position always to check the orders of the captain. The experience which would be gained by the crew of such a tugboat in the movement of vessels would doubtless be a sufficient guarantee of freedom from collisions with the gates. The great length of the Panama locks would permit the use of such a tugboat without difficulty.

Other means might be available for the movement of vessels, such as electric towing locomotives on tracks alongside the locks. It is not our purpose, however, to consider any such schemes in detail, but to point out that American engineering ability is certainly equal to the task of reducing to a negligible quantity the danger of collision with lock gates in a ship canal lock; and that it would be absurd to discard the use of locks entirely in preference to adopting measures to make their operation safe.

The vast annual fire loss of the United States is universally conceded to be a National disgrace. At the recent annual meeting of the National Fire Protection Association, reported in our last week's issue, a series of resolutions was adopted urging greater attention to matters of fire protection. We print these resolutions in full as follows:

Whereas, The National Fire Protection Association was formed ten years ago "to promote the science and improve the methods of fire protection; to obtain and circulate information on this subject and to secure the

cooperation of its members in establishing proper safeguards against loss of life and property by fire," and,

Whereas, In spite of all efforts up to the present time the terrible fire waste of this country has continued uninterrupted involving a loss per capita several times greater than other countries, and,

Whereas, Public protection has not kept pace with the growth of buildings and increase of valuation in congested centers and as the business conditions and prosperity of the country are liable to interruption if this increasing loss cannot be checked,

Be It Resolved, by the National Fire Protection Association in convention assembled that an urgent appeal be and is hereby made to all interested to cooperate in bringing about better conditions by adopting improved methods of construction, by safeguarding hazards of occupancy and by introducing automatic sprinklers and other private protection with private water supplies quite in addition to the Public Fire Service, and

Be It Further Resolved, That we recommend that municipalities pass ordinances involving the adoption of an approved building code along the lines of the building code recommended by the National Board of Fire Underwriters, and requiring the introduction of automatic sprinklers with private water supplies, in buildings of special occupancy and in so-called congested districts, to the end that the danger of sweeping conflagrations may be largely eliminated.

While the above resolutions place improved construction first, greatest stress is laid on more efficient means of fighting fire. We make no criticism of this, for unquestionably what we have to deal with is existing buildings, nearly all of them built of inflammable material and an easy prey to fire. To reduce our national fire loss during the next score of years, we must place almost sole reliance on better means of fighting fire. At the same time it must not be forgotten that prevention is better than cure, and the cities and towns in which the next generation will live, must be made as free from fire danger as are the cities and towns of England and Continental Europe. This can only be done by radical reforms in our methods of building, and the time to put these reforms into practical effect is the present time.

The current discussion on the Panama Canal plans is serving without doubt to considerably enlarge the knowledge of the engineering profession with respect to the construction of earth dams on soft and permeable foundations. A notable example of such work is illustrated and described in the present issue by Mr. J. W. Ledoux. This dam, recently built to impound a water supply for Charleston, S. C., was made across an alluvial swamp filled with material of a peaty nature and underlaid by 10 ft. or more of fine sand. In building the dam, no attempt whatever was made to excavate or dredge, but the earth of the dam was simply dumped in place on material so soft that the marsh rose up in waves along the line of the dam and 50 ft. away from it.

This dam is built where tightness is essential since the stream whose waters it impounds runs nearly dry at certain seasons of the year. No doubt engineers could be found who would claim that the water would percolate away through the sand underlying the dam and that the consequent erosion would soon wreck the dam. The dam, however, appears to stand and do its work to the satisfaction of all parties concerned.

SOME CONSIDERATIONS AS TO SAFETY IN THE OPERATION OF ELECTRIC INTERURBAN RAILWAYS.

Electric interurban railways are now to a large extent passing through a phase of development by which comparatively short and isolated lines are being interconnected to form long routes and comprehensive "systems," often under a single management. On the more important lines there is also a development in service and speed, and deficiencies in construction, equipment and operation become more serious with these developments. Under such conditions increased care in the operation of the service becomes very necessary, although many of the smaller interurban lines are operated on a "horse-car" basis as far as discipline and systematic management are concerned. In this review of matters affecting the safe operation of electric interurban railways, we are dealing more particularly with the larger and important lines. The great majority of lines of this class have but a single track, and as a rule a 30-minute service is considered the maximum safety for single track lines, especially where high speed is maintained. On some roads, however, 15 and 20 minute schedules are maintained, occasionally with a signal system as an additional safeguard.

In the construction of railways of this class, even for important lines, the location is often governed far too much by right-of-way considerations, and operating conditions are correspondingly subordinated if not entirely overlooked, as being of secondary importance. The right-of-way agent has usually little regard for either engineering or operating conditions, and in many cases, therefore, the engineer has to locate a line to lie within such land as the agent has secured as a donation or at low prices. As he has usually also to fit his line pretty closely to the ground in order to avoid heavy earthwork and large structures, he is under such conditions hardly to be blamed if his road is a poor proposition from an operating point of view. Sharp curves and steep grades have been the cause of many accidents, especially to cars run at high speed. Such a line, however cheap, may be dear at its cost, but the relations of construction to operation, and (through operation) to the financial results, are rarely realized or given consideration by promoters and financial backers of these railways.

The point to these remarks is pressed home with a force to be felt by everyone by the accident at Providence, R. I., noted in another column of this issue. Here was the case so often observed of a sharp curve at the foot of a hill, a management that permitted a motorman practically unacquainted with the line to make a fast night run with a crowded car of merry-makers, and no signal system to mark the danger spot. Every circumstance conspired to bring disaster, and disaster came. The car took the curve at high speed, its body was wrenched from the trucks and hurled from the track onto its side. Scarcely a person aboard escaped injury, and eleven boys and girls were killed. The fatal results alone of the accident mark it, but its real horror lies in the fact that it was the outcome of conditions that are exemplified over and over in the alinement and location of electric railways.

We have in mind a case where the engineer of a line intended from the first for high-speed service in competition with the main line of a steam railway was severly criticized by his employers for using long, easy curves, and was in at least one instance compelled to put in a curve sharper than he considered advisable, or even safe. He was told that "an electric car can go anywhere." He pointed out that the sharper curve occurred on a stretch of line between two stations where cars would be running at high speed, and that it would be an element of danger. It would probably be necessary to put up a speed caution sign or to issue special orders for this curve, and it would then be safe only as long as motormen could be relied upon to slacken speed for the curve. But through carelessness, recklessness or a desire to make up time, these men are apt to neglect such precautions. If nothing happens the first time they will get in the habit of neglecting them, until some time the speed is a little too high and an accident results.

In regard to structures, there is usually little fear, except where promoters wishing to use public roads and bridges agree to take the responsibility (and risk) of running cars over old and light highway bridges. As a rule, the local authorities object to this use of their bridges, and the railway company builds its own trestle or steel or concrete bridge. These new structures are not apt to be open to criticism for insufficient strength.

The cars themselves are now usually built with underframes strong enough to withstand collisions, but if there is any difference in height the frame of one may ride over the other, shearing away the lighter superstructure. This is one reason for the desirability of uniform weight of frame, which may be eventually arrived at by standardization, as noted below. Trucks should be stiff and strong in construction and well [illegible] with springs that will not only absorb shocks but check the vibration of the body which is so annoying in many high-speed interurban cars. Owing to the amount of mechanism to be carried on the trucks, the endeavor has been made to use only coil springs, but generally with unsatisfactory results; elliptical springs between the bolster and spring plank appear to be necessary to secure an easy-riding car. The brake equipment is usually ample, although the percentage of weight braked is sometimes too low, and an electric car (or even two or three cars) can generally be controlled more readily than a steam train. Carelessness in the use of brakes, however, is too frequently observed, especially in descending grades where excessive and dangerous speeds are too often allowed; the danger is, of course, increased where sharp curves exist on or near the grade. It may be said, also, that both in steam and electric railway operation the brake is made a convenient scapegoat, and the excuse that the brake would not act is made for all kinds of accidents. The cars must, of course, be heavy enough to avoid danger of jumping the track under the influence of severe joints or vibration.

Collisions are the most frequent among electric railway accidents, and are due very largely to lax discipline or unsystematic methods of handling the traffic. Most lines of this class are single track, and through misunderstanding or disregard to orders collisions occur at or between the passing sidings. Safety of operation, therefore, is a most important point for consideration, but on electric railways the rules are not usually as carefully prepared or enforced as on steam railways, while discipline is as a rule much poorer. Since accidents occur under the higher order of things on the steam railways, they must be expected to occur under the conditions existing on electric railways. Fortunately, the accidents are rarely as disastrous on the latter. The collisions usually occur between single cars, and as these are as a rule equipped with good brakes it is easier to check their momentum.

Coming now to methods of operation, the most general system is that of telephone dispatching. Under this system, telephones are fitted at the terminals and passing sidings, and the cars are run by schedule or train order. The crews report by telephone to the dispatcher at certain points, and can thus be given special orders as required. Portable telephones on the cars and connections on the poles at frequent intervals enable the crews to call up the dispatcher at practically any point in case of emergency. Should a car be behind its regular time special orders can be given it, so as to ensure safe running and to avoid interference with other regular cars.

The system is in principle very similar to that of telegraph dispatching and train orders in steam railway service, and in some cases the standard rules are adopted with a few necessary modifications. On the electric road there is no operator to act as intermediary between the dispatcher and the crew, but the former communicates directly with the conductor or motorman. It is considered by some that it is safer to have the orders given to the crew by an operator, such as a car starter or station agent, but it is rarely that this is possible. In the earlier days of operating under this system too much reliance was frequently placed upon the verbal orders (following the practice of "horse-car" days), no records being kept; this led to trouble in handling even the regular cars, and the trouble was accentuated when extra cars, work trains, etc., were interpolated. At the present time, however, most of the important lines have complete systems of records, the conductor writing down the order in duplicate or triplicate on printed blanks, copies of which are filed as evidence in case of dispute.

In the elementary system still used on many roads, the cars are expected to pass each other

at scheduled meeting points, but in case of derangement of the schedule may receive special orders from the dispatcher by telephone. Some of the important roads, however, use a more advanced system, under which no movement is permitted on single track without specific and written orders from the dispatcher. Thus on the Boston & Worcester Ry. all orders for movements over the main line are written in triplicate, one copy going to the motorman and one to the conductor, and the third being retained for record. At points where there is no car starter or agent, the orders are written from the dispatcher's dictation, the conductor using an autographic register located in the telephone booth. The order must be repeated back to the dispatcher, who gives his "O. K." and the time before it becomes valid.

A few roads use the telegraph instead of the telephone, as being the safer of the two; but that is generally when the management and employees have had experience in telegraph working on steam railways. The Puget Sound electric railway between Tacoma and Seattle, Wash., is operated under the standard rules and regulations of steam railway service, but using both telegraph and telephone; the former is considered preferable and the latter employed as auxiliary to it. This road has 44 miles of single track with passing sidings at 28 stations (besides 21 stopping places not so provided); it operates 67 regular trains a day, running at speeds of 45 to 60 miles an hour, and all movements not provided for by the time table are regulated by train orders issued by the superintendent. At eight of the 28 passing places there are telegraph operators, and at the others there are telephone booths. If a car is 5 minutes (or more) behind time the conductor must report by telephone to the dispatcher at the first station and get special orders; if the next station should be one at which there is an operator, however, the operator will have reported the car as being late and will probably have orders ready for the conductor.

To reduce the number of orders and the delay from writing them, it is desirable to have a single order cover a considerable portion of the route, but in electric railway work it will usually be found that local conditions limit the distances which it is expedient to cover with a single order. In many cases the dispatcher would be more willing to give a long-distance order if he had better facilities for stopping a car and changing the order, but usually this can only be done at points where stations, car houses or electric sub-stations provide attendants who can be called upon to flag a car. Even then, good discipline is required to ensure this being properly done, and the possibility of being too late to flag or stop the car must be considered. Thus the dispatcher is at a disadvantage in not being able to get in touch with the cars, and a system by which he could do this would be a great help and safeguard in many cases. Such a system is already in use and enables the dispatcher to display a signal to attract the attention of the crew and notify them to call up the office for orders. He can also use it to remind them of orders to stop at special points other than the usual stops, as force of habit often causes men to forget such changes from the regular routine. While this system is in service or in course of installation on a number of roads (aggregating about 250 miles) these, of course, form but a small proportion of all roads using the telephone dispatching system. It does not in any way fulfill the duties of a block signal, but is simply a train-order signal, while the possibility of a signal being displayed after the car has passed must also be considered.

In the telephone dispatching system, failure in communication is usually due to lightning or the accidental presence of the trolley currents on the telephone wire. Both of these cause the burning out of instruments. Broken telephone wires sometimes occur, as well as derangements in the instruments; but the latter can usually be found and remedied before the instruments go altogether out of service. The best protection against the effect of lightning and stray currents seems to be the enforcement of a rule to keep all instruments cut out of circuit when not in use. A further protection, and one that it will often pay to adopt at important points, is to have duplicate instruments ready to be connected up at a moment's notice. This is done quite extensively by the Boston & Worcester Ry., which even has three instruments at some places. Additional security against interruption of service is the installation of telephones of the public telephone company, at all car barns, sub-stations, waiting rooms, etc., in addition to the electric railway company's private system.

The block signal system is very little used as yet on electric interurban railways, and in fact is not generally regarded with favor; this is due no doubt to the limited experience with it. In very few cases where block signals are used are they relied upon entirely, being generally regarded as auxiliary to the dispatching system. The larger signal companies have not given very much attention to this particular field, but there are smaller companies making this a specialty; while the engineers of some lines have devised more or less elaborate systems of their own. Manual signal systems are, of course, out of the question, the traffic and revenues of the companies not warranting such installations, but the gradual introduction of some cheap but efficient and reliable automatic signal system may reasonably be expected within the near future. Most of the railways being single track, the signal system must provide for both opposing and following cars, with intervals of from 15 to 60 minutes between cars. But even on double-track roads, especially in hilly country, there is considerable opportunity for rear collisions, so that the block signal as a means of keeping cars a certain distance apart is probably needed as much on double-track as on single-track.

It is sometimes claimed that where both slow and fast (or "limited") cars are operated, an automatic block signal system would interfere with the latter service, a regular car or freight car holding back the "limited" car. But the latter needs to be held back a proper distance for the sake of safety. The schedule would naturally be so arranged that the slow car would reach a siding in proper time to clear for the following fast car, and would have orders to wait at that siding till the latter had passed. If for any reason it lost time, the signals would protect it from the rear until it reached the siding, but the crew would have to show some good reason for thus detaining the "limited." The dispatching system does not thus protect against rear collisions. It it obvious that this block-signal system would be safer than a dispatching system, even with train-order signals, and it would lead to a much closer observance of schedules than is now usual on many interurban lines. It is sometimes claimed also that with the dispatcher's train-order signal system in use (as already mentioned) the crews would not have to call up the dispatcher at meeting points unless they found a signal displayed. This would not be safe practice, however, since the dispatcher would not know the whereabouts of the crew he wanted to get hold of. It would seem much better that at some points on the run they should notify the dispatcher if they are on time, etc. Of course where there are stations and operators this need not be done, the operator reporting the car and transmitting to the crew such orders as may be necessary.

Isolated sections of block or interlocking signals are occasionally used to govern the movements of cars on steep grades or difficult portions of the railway, and sometimes in cities where the street car lines form part of loops or junctions for interurban lines. Some railway companies have apparatus of their own design for such purposes, thus preventing confusion in handling the cars for the various routes. Switches at passing places, etc., are generally equipped simply with a switchstand and target, but in many cases something more distinctive than this, or even a distant signal, would be very desirable.

Grade crossings of high-speed electric lines with steam railways are very generally protected by interlocking plants. But long detentions of the cars and occasional derailments due to motormen overlooking the signal or trying to rush the crossing (forgetful of the derails) indicate the desirability of a separation of grades, especially on high-speed electric lines. In many cases the cost of an overhead or underground crossing would be little more than the cost of an interlocking plant and the capital cost for maintenance and operation, but promoters are apt to overlook this and to consider that in avoiding a grade crossing they are in some way allowing the steam railway to get the best of them. For road crossings, special precautions are often necessary, as the cars approach so noiselessly and swiftly; for such crossings automatic gong signals are used in a number of cases. There is, of course, a rule for whistling at all such crossings, but the air whistle is usually feeble as compared with a steam whistle, and motormen appear to have a universal objection to obeying this rule properly, if at all.

One other point that may be mentioned as affecting both safety and facility in the operation of traffic, especially where through cars pass over different lines, is that of uniformity in such matters as car clearance limits, width of cars and height of frame, distance between centers of tracks on double track and at passing sidings, form and dimensions of wheel treads and flanges, etc. Cases are on record where through routes have been found to be impracticable owing to the insufficient headway under certain bridges prohibiting cars of one line from passing over a connecting line using smaller cars. The matter of wheels is a rather difficult matter owing to the fact that most cars have to run through streets as well as on the open track. A large wheel flange that may be considered as desirable for safety at high speed may be too large for the flangeways of street tracks (especially where grooved rails are used) and may prove destructive to the switches, frogs and special work, and also to the paving. On the other hand, the small flange and narrow tread of the wheels of an ordinary city car may be quite insufficient for safety as applied to a heavy interurban car for fast service. In several cities there has been strong objection by the public authorities against the entrance of interurban cars upon the streets, owing to the damage done to the paving by the wide treads and deep flanges of the wheels. Where cars are run at high speed along country roads there is greater danger of derailment than on a private right-of-way with open track, especially if the size of the wheel and flange is reduced on account of paving considerations, as a slight obstruction in the flangeway may lead to derailment.

In conclusion it may be said that there are evidently a number of matters which demand the attention of the engineers and managers of electric interurban railways as affecting the safety of operation of these lines; and that on the other hand, conditions of traffic and revenue make it essential that the cost of safety appliances for lines of this class must ordinarily be very much less than those used for similar purposes on steam railways.

LETTERS TO THE EDITOR.

Allowance for Impact on Ballast Floor Bridges.

Sir: L. F. V. asks in Engineering News of May 17, p. 544, whether the impact of the moving load should be computed as usual for a span with a ballast floor carrying 2 to 3 ft. of ballast.

The Schneider-Thompson impact formula, and any specifications using it require the same allowance for impact on a bridge of this design as on one with an ordinary wooden tie floor.

The Pennsylvania R. R. specifications use a formula for impact based on the ratio of the dead load stress to the maximum stress, or rather the ratio of the minimum stress to the maximum stress. This, in the case mentioned by L. F. V., would require an allowance for impact considerably less than the allowance for a bridge in which the dead weight was smaller. This, it

will be seen, is the mean between the extremes of excluding impact altogether and of making the same allowance for a bridge with a lighter floor. "Impact."

New York, May 28, 1906.

[We have in press at the present time a set of specifications for standard railway bridges, prepared by Mr. A. W. Buel, Consulting Engineer, which gives a formula for impact that takes into account the ratio of the minimum dead load stress to the maximum stress.—Ed.]

More Graft for Engineers.

Sir: The communication on "commission graft" of "W. E. H.," in this week's News, prompts me to ask the following question: What about "fixing up" the engineer and inspector on municipal work?

I have charge of some sewer work, and here is the story of it: In the very beginning the inspector was offered a position as a "foreman;" a week ago the sub-contractor's superintendent extended to me the sinister hand of corruption, and upon my refusal to accept it, exceedingly amazed, he explained: "This is nothing; we do it every day in Philadelphia." A few days ago a representative of the Security Co. came around to see the progress of the work, and his inquiries about the engineer centered about his being "fixed up." On speaking of this to my chief I learned that it is a common occurrence for intending bidders to come to him and ask what he considered his share of the profits on the proposed contract.

I am only a year out of college, and my experience may not be representative—yet "we do it every day in Philadelphia" points to the fact that there must be a class of engineers who are ready to sell their conscience. Is it not time now, when even "gang" councilmen "reform," that such engineers should reply to unscrupulous contractors with "Get thee hence, Satan?"

Yours truly, A. "Sheff."

—, New Jersey, May 25, 1906.

Oil Separators for Exhaust Steam.

Sir: Upon reading the article in your issue of May 31, descriptive of the Pennsylvania R. R. Co.'s Long Island City power station, we find a point to which we would take serious exception We quote from the first lines of the second column on p. 594:

> The Westinghouse single-acting engines driving auxiliary machinery do not send their exhaust steam to this heater on account of particles of crank case oil that may work into the exhaust.

While the engineers of this plant may not believe that the crank case oil can be removed from the exhaust steam by an oil separator, and while it may be true that many makes of oil separators are not efficient enough to remove this oil, it is a positive fact that Cochrane oil separators, when installed to meet these conditions, will remove this oil. The exhaust steam from the Westinghouse single-acting engine in our own plant has for years been passed through a Cochrane oil separator into a Cochrane feed-water heater from which our boilers are fed, and we have absolutely no trouble from oil in the boilers. We could give you the names of a number of other plants in which our Cochrane oil separators give thoroughly successful and satisfactory service in taking the oil out of exhaust steam from Westinghouse engines.

Very truly yours,

Harrison Safety Boiler Works,
R. H. Ramsey.

Philadelphia, Pa., May 31, 1906.

Possible Accidents to Panama Canal Locks.

Sir: In your issue of May 31 you have an editorial on the subject of the Panama Canal under the caption, "What Is Worth While." As I have read all the literature I could find on the subject, as well as the articles in previous issues of your paper, I can not help asking you whether, after you have given the matter further consideration, you think that you have stated the arguments of the sea-level advocates quite fairly. I refer to a paragrah on p. 608, reading as follows:

> The basis for this assertion rests on a hypothetical assertion by some of the sea-level advocates regarding the possibility of accident to a ship in passing through a lock.

Unless I have been very careless in reading the literature on the subject, or else am duller of comprehension than the law allows, the danger apprehended is that damage may be done to the locks by passing vessels, and that would, it seems to me, be a much more serious possibility.

I should much like to know through the columns of your paper whether, as you have better opportunities for being correctly informed on this subject, you think this view is erroneous, and, if not, what criticisms you have to offer against that objection. Yours truly,

"An Admirer."

Washington, D. C., June 1, 1906.

[Our correspondent's criticism is well founded. We should have referred to the alleged danger to the locks or lock gates rather than to the ships passing through them. In our editorial columns of this issue, we have discussed in somewhat greater detail the question just how "serious" this possibility of accident may be.—Ed.]

Why Not Fill in Behring Straits?

Sir: "From New York to Paris by Rail" is the title of an article in the May number of the Review of Reviews, by Rosenthal, as proposed by M. de Lobel, who is now in Russia. On the supposition that such a railroad will be built in the future, would it not be better and just as cheap to fill in Behring Straits as to build a double-track tunnel as proposed by M. de Lobel, with an abundance of rock close at hand and a rock foundation to build on. A breakwater could be built by the way of the islands for no more than what a sea-level canal would cost at Panama, say 190 ft. high in the deepest part and 30 ft. across on the top, slopes 1 on 1. What might be still better, would be to cross the straits at the mouth of the Yukon River and St. Lawrence Island, where the depth of water is about half as deep as at Behring Straits; though the distance is twice as far or more, it would take but little more material. The St. Lawrence Island is about 80 miles long, east and west, and lays in the very best position. The depth of water at the straits will average 26 fathoms, and east of St. Lawrence Island it is about 13 fathoms on an average, and west of the island it will average about 18 fathoms. St. Lawrence Island is about 100 miles farther south. This route will save at least 200 miles of expensive road, and keep south of the Stonavi Mountains, near the coast, and avoid much cold and rough country.

This project would give rise to a scientific question, if the arctic currents were shut off from flowing south and the warm currents from the south, held back to the Aleutian Islands, would it not modify the climate along the Alaskan and Russian coast? This, in itself, might be worth the expense. As an international project it would not be too great. Respectfully, R. J. Mershon.

1317 West 105th St., Chicago, Ill., June 2, 1906.

[Our impression is that the depth of water in Behring Straits has been placed at as high a figure as 300 ft., which would make the building of an embankment across a truly herculean task, to say nothing of making a submarine tunnel of doubtful possibility. However, it is yet to be demonstrated that any one really desires to travel from New York to Paris by way of Behring Straits and Arctic Siberia.—Ed.]

The Character of Construction of the Stanford University Buildings Injured by Earthquake.

Sir: I am in receipt of a copy of Engineering News of May 10, containing a report by Mr. Edwin Duryea, Jr., on earthquake damages at Stanford University, and If you will permit me I would like to contradict some of the mis-statements contained therein.

The Museum was designed by Percy & Ha[illegible], of San Francisco, and is built of reinforced [illegible]crete, Dyckerhoff's cement being used and furnished by [illegible]nator Stanford. The first addition, to this building, [illegible]n in your illustration, Fig. 5, Engineering News, [illegible] 10, 1906, was designed by the same firm, and built [illegible] brick, stuccoed. The later addition, starting with the [illegible]unda and dome, as shown in the same illustration, [illegible]s designed by myself, and is of steel construction [illegible] brick and stuccoed walls. This rotunda, with that co[illegible]ponding at the farther end of the building, is intact except for a few cracks in the brick walls, showing that the brickwork was well bonded and the mortar good.

The statement that Eucina Hall was not d[illegible]ed is incorrect, as the south walls of the east and w[illegible]wings were badly fractured by the earthquake, and [illegible] have to be rebuilt, although this building is one o[illegible] best constructed on the Pacific Coast. In the Ho[illegible] Gymnasium the roof timbers and steel trusses, of 100 [illegible] span, over the gymnasium and drill hall, are still int[illegible] being supported by steel columns from the foundati[illegible] therefore the statement that "the only example of steel construction is the dome of the new Library Building" is likewise incorrect.

All of the one-story buildings, with one exception, and of which I was not the architect, around the outer and inner quadrangle, are intact, but the triplet gabled arch, forming the entrance to the inner quadrangle, was thrown off the columns 5 ins., as shown by the accompanying photograph.

A direct contradiction that "weak lime mortar" was used, is proven by the stone and bricks that have fallen in bulk from the top of the Memorial Arch, a height of 100 ft.—and many like instances can be seen.

The earthquake has plainly demonstrated the errors made in the construction of buildings, and very few withstood the shock unless reinforced with steel, and I fail to comprehend the motive of your correspondent, living in this community, who sent out such an unfair statement. I have been associated with the University for the last 17 years, and the work since the completion of the inner quadrangle has been the same throughout, i. e., stone veneer, the University supplying all the cement.

In conclusion, I would ask you to publish, in conjunction with this article, the enclosed statement by Trustee Geo. E. Crothers, which was published in the San Francisco Examiner of May 2. Respectfully,

Chas. Ed. Hodges, Resident Architect.

Architect's Office, Stanford University, Palo Alto, Cal., May 20, 1906.

[Mr. Crother's statement, a copy of which was enclosed by our correspondent, is as follows:—Ed.]

Editor of the Examiner: Dear Sir: I am sure you will be glad to correct some errors in your paper of to-day relative to the Stanford University buildings. Owing to the constant prevalence of false but apparently authentic reports at Palo Alto relative to university matters, due in part to the absence of official statements of facts, your representative has shared the lot of many others in being led into making several seriously inaccurate

VIEW OF ARCHED ENTRANCE TO INNER QUADRANGLE, STANFORD UNIVERSITY, SHOWING MOVEMENT OF ARCHES ON SUPPORTS BY EARTHQUAKE SHOCK.

statements tending to reflect upon individuals and to discredit the institution.

Your representative states: "Six million dollars was set aside to construct the library, the gymnasium and the Memorial Chapel. Experts who have viewed the ruins of these buildings declare that they could not have cost more than $3,000,000." With this as a basis, he says: "But so far as the faculty is concerned the entire $6,000,000 was expended by Architect Hodges, Contractor J. G. McGilvray and C. G. Lathrop, brother of the late Mrs. Stanford and treasurer of the university."

The fact is that these three buildings have cost the university approximately one-fifth of the amount named as the actual expenditure, and much less than one-half of the amount alleged to have been stated by experts as their reasonable maximum cost. Indeed, the whole university plant cost much less than $6,000,000. The university has suffered severely from the exaggerated reports of the cost of its buildings. With few exceptions they are severely plain and of simple but substantial construction.

Of the three buildings referred to above Mr. Hodges was the architect of the gymnasium only, though he supervised the construction of the new library building. The architect of the church and library was a San Francisco man who was the architect of several of the few city office buildings not injured by the earthquake. All important contracts were let by Mrs. Stanford personally. After Mrs. Stanford's death the erection of the library building was under the sole control of a board of three trustees appointed by Mrs. Stanford. Before accepting the completed work they had it carefully inspected and reported upon by one of the most reliable builders in the country. The completion of all other buildings under course of construction devolved upon the Finance Committee of the Board of Trustees, consisting of seven members.

The statement that wood construction was inserted in the buildings in excess of that allowed by the specifications is almost certainly without any foundation of fact whatever. Mrs. Stanford had a wonderful knowledge of the details of construction, and they were also thoroughly known to others concerned. In general the contractors more than met the requirements of the specifications in this respect.

It is a sufficient answer to the statement that the mortar used in the recent buildings was inferior to state that, with one exception, the university furnished to the contractors high-grade cement ad libitum, without deduction for cost, for all mortar and concrete, and that a single reliable person supervised the mixing of mortar for all but the original university buildings.

All university buildings in which stone is used, of more than one story in height, including the great men's dormitory, erected by Shipley, Routan & Coolidge, the original architects of the university buildings, are of brick with a sandstone veneer. This was required both by considerations of economy and strength. A few of the one-story buildings were also erected of brick with sandstone veneer. Solid stone would have been preferable in these low buildings, but they were erected when money was scarce. Few, if any, of the architects use solid sandstone in buildings as high as the larger buildings at Stanford. On the other hand, sandstone is used only as a veneer on a brick wall in nearly all of the very best stone buildings recently erected in San Francisco. Considering the severity of the earthquake the brick and stone walls of all of the completed buildings at Stanford stood wonderfully well. The damage to these completed buildings is in every case superficial and easily repaired. They fared fully as well as could be expected of buildings not of steel frame construction and easily can be rendered almost as safe.

With the exception of the loss of the front gable, the damage to the church was due to the falling of heavy stones from the upper portion of the tower. These stones were not originally provided for in the plans of the architect and will doubtless not be replaced. With the exception noted above the walls of the church, the windows and the mosaics are not seriously injured.

While I am a member of the Board of Trustees, I write this solely as an alumnus who is familiar with the facts stated and interested in the welfare of Stanford.

Respectfully, Geo. E. Crothers.

The Hill Plan of Excavating the Culebra Cut.

Sir: In answer to your somewhat indefinite criticism of my plan for the excavation of Culebra Cut in the Engineering News of May 17, 1906, allow me to call your attention and that of your readers to the following points:

The work under discussion consists of the following general items:

(1) Drilling.
(2) Explosives.
(3) Loading and dumping.
(4) Transportation.
(5) Plant.
(6) Administration.

Items (1) drilling, (2) explosives and (6) administration, should be practically the same under any method adopted.

This leaves for our special consideration the three items (3) loading, (4) transportation and (5) plant. Now if you please we will separate this work into its different parts, giving definitely what belongs to each.

In my plan loading will begin with the steam shovel and end when the material is dropped into the shaft by the Lidgerwood cableway. Dumping will be considered from the time the train leaves the main line of the double-tracked Panama R. R. until the material is in place in the dump.

Transportation will begin with the operation of the trains after receiving the material, and so that we may look sharply at this matter we will eliminate operation over the Panama line, which will be the same in any case, if the cars are full loaded, and bring the proposition down to its proper consideration, which is the difference of work by the different plans, inside of the ends of the cut.

LOADING.

It may seem strange to say that it is cheaper, more rapid and more reliable for a shovel to load into skips, to be taken away by a Lidgerwood cableway, than directly into a car, but this is a demonstrated fact. After all the new and novel ways tried on the Chicago Drainage Canal (nearly as big a job as the Panama), where all our greatest development in handling large quantities of rock and dirt was made, the cableway was found to be the most economical, rapid and reliable way to excavate. The reason for this is very simple. No contractor has yet been able to get sufficient cars under a steam shovel so that the shovel can work at full capacity. It has been demonstrated, however, on the Chicago Canal, and is being actually done now, every day, on the St. Mary's Canal, under the U. S. Government engineers, on Mr. C. H. Locker's work, that a Lidgerwood cableway will take away easily the utmost capacity of the largest steam shovel, thus allowing over the car method a gain of nearly 30% in results.

The operation, under my plan, for this surface work is, you will see, by a study of what has been done, exactly the practice of the best contractors on the largest pieces of work done to date, several of which compare in size to Culebra Cut.

TRANSPORTATION.

Under the plan of loading at the shovel a train will haul its load, within the cut, over a temporary track. This will require slow movement of trains, and has resulted at Panama, and always will, under anybody's management, in daily wrecks, and will show up in cost in the coal bill in a most discouraging amount.

All practical railroad men will tell you that the better the roadbed, the straighter and more level the line, the cheaper will be the cost of haul. Now, under my tunnel plan, the tracks are straight, level and, being permanent, for, say each six years of the work, it will pay to have them well ballasted, and my method of construction would give us plenty of ballast at hand.

My plan calls for the ordinary railroad cars, such as are in daily use in this country, and which I see the Government is now shipping to Panama in large numbers.

If you will stop and consider the cost of hauling up steep grades into the cut, the empty trains an innumerable number of times per day for years, you will see that the cost of the shafts will be well repaid, when they allow the material to be dropped down to the level tracks in the tunnel without appreciable cost. A car will weigh one-third to one-half of its paying load, and the cost, operating by cars in the cut, for hauling up the empties, will be more than hauling down the loads.

DUMPS.

On page 131 of the report of the Isthmian Canal Commission, in the statement of approximate cost for year July 1, 1904, to June 30, 1905, the item of dumps cost is given at 0.0547 per cu. yd. With the plan presented by me I would gladly undertake the work for $0.04 per cu. yd., which would show a saving at this point of about $1,000,000.00 on Culebra material alone in this one small item of this great work.

PLANT.

My plan of transportation consists essentially of the following factors different from those now used.

Forty-four shafts 50 to 150 ft. deep, 8 x 10 ft., 8 miles of tunnel (three-track size), 24 miles of railroad (8 miles of three tracks).

As against these will be by the present method, to care for, say 100 shovels, 250 miles of temporary tracks, which must be continuously shifted as the shovels move along in their cuttings. Every mile of this track will cost $15,000 in place for the first time, and every mile will cost $500 each time it is shifted, and will cut off the product of the steam shovels while being shifted. If these tracks be shifted four times per year for twelve years you will have a cost of $24,000 per mile of track for shifting.

It resolves itself to this question, Is the cost in my plan of the shafts, tunnel and track and their maintenance equal to the cost of the temporary tracks, and their maintenance during, say, twelve years. Is the evident difference in favor of my plan, in cost of operation per cu. yd. of excavation after installation, when multiplied by sixty million (cu. yds.) an item for consideration where every penny per cu. yd. saved in cost of operation means $600,000.

As to your suggestion that the temperature in the tunnel would be intolerable I will call your attention to the fact that in my tunnel plan the shafts from 50 to 150 ft. high every 1,200 ft. will act as chimneys and create a natural draught through the tunnel continuously. The Chicago subway is connected with the chimneys of the buildings adjacent, and as a result there is an abundance of ventilation, although it is a deeper tunnel with much smaller bore, much more crooked and naturally less easily ventilated.

You will find by investigation that the subway carries in live human freight much more tonnage than is proposed by my system for carrying the dirt and rock necessary to excavate the Culebra Cut. If it is safe to carry human beings in a tunnel at 30 miles an hour, it is surely safe to calculate on carrying dirt at 15 miles per hour. Yours truly, Fremont Hill.

New York, May 19, 1906.

Notes and Queries.

In an article on vanadium steel alloys on p. 582, of our issue of May 24, was the sentence:

The chrome-vanadium steels containing 10 to 20% vanadium show the most remarkable properties, the highest test yet obtained, after special heat treatment, being a maximum breaking strain of 103 tons per sq. in.

A correspondent suggests that steel containing this amount of vanadium would be valueless.

These percentages were copied directly from a consular report without noticing the probable error in placing the decimal point.

ANNUAL CONVENTION OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS AT MILWAUKEE, WIS.

(Concluded from page 630.)

light than a 450-watt carbon arc. On the subject of analysis and explanation of the action of mercury-vapor apparatus, he disagrees radically with the author. In his view the mercury-vapor tube behaves essentially like every arc, whether carbon, magnetite or other. Concerning the supply of series arc circuits by vapor converters, he stated that any practicable number of arc lamps in series may be supplied from a single converter, as the converter can be operated with safety up to 10,000 volts. Several lighting systems of this type, with a total voltage of 4,500 to 7,000 volts, supplied in each case through a single converter, are at present in commercial operation.

A paper on "The Art of Inventing," by Mr. E. J. Prindle (New York, N. Y.), was discussed by Mr. C. P. Steinmetz. A paper entitled "Some Notes on the Lighting of Churches," by Mr. E. R. Weeks (Kansas City, Mo.), describing the illumination of a church of medium size, showed an

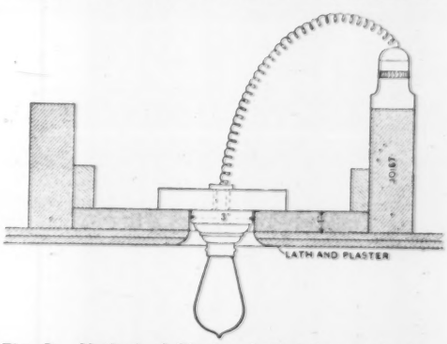


Fig. 3. Method of Placing Ceiling Lamps in An Electrically-Lighted Church (E. R. Weeks).

ingenious arrangement of ceiling lamps, illustrated in Fig. 3 herewith. The block carrying the lamp fitting may be lifted upward into the attic for cleaning or renewal of lamp.

Two papers were read by title only: "Electrical Connections for Power-Houses," by Mr. D. B. Rushmore (Schenectady, N. Y.), and "Safety Devices for Steam Engines, Turbines and Motors," by Mr. C. M. Heminway (New York, N. Y.). In connection with the last-named paper, Mr. W. L. Emmet described a speed-limit safety which has been devised for the Curtis steam turbine. The main throttle valve, when open, is held up by a set of toggle levers, and above these is a weight so disposed that in falling it will knock out the toggles so that the valve drops and closes. The weight is itself held up by a pair of toggles, which are adapted to be knocked out by a centrifugal device on the turbine shaft. A metal ring somewhat larger than the shaft surrounds the shaft, and is guided by two radial pins in the shaft at diametrically opposed points. At one of these pins there is a spring which tends to force out the corresponding side of the ring. A stop on one of the pins allows the ring to follow the spring only so far as to leave the center of gravity of the ring slightly out of center with the shaft, and on the side opposite the spring. The device is so adjusted that when a certain speed is comes the spring pressure, and throws the ring reached, the centrifugal effect upon the ring overout on the opposite side. In this position it strikes and shifts a lever which knocks out the toggles supporting the releasing weight; the latter drops and the valve closes.

THE NEW WATER SUPPLY FOR CHARLESTON, S. C.*

By J. W. Ledoux,† M. Am. Soc. C. E.

In the early part of the seventeenth century Charleston, S. C., was located about twenty miles southwest of the present site on the banks of the Ashley River, and there are now evidences of that settlement in the shape of old ruins, one being known as the old Spanish Fort, made of concrete composed of shells and mortar. There are many other interesting landmarks of Charleston's previous history, one being the Goose Creek Church, which appears to be in about the same condition as it was one hundred years ago; and there is a society, known as the Goose Creek and St. James Parish, which has perpetuated its memory by holding services in this church once a year ever since. Some of the churchyard graves date back to the seventeenth century. There are several other places of equal antiquity and historical interest.

About 1678 the settlement on the Ashley River was abandoned on account of the encroachments of the Indians, and the settlers moved to the peninsula between the Ashley and Cooper rivers, the present site of Charleston.

In those days, the inhabitants being few, water was taken from shallow wells, but as the population increased it was found that the wells became hard, impure and injurious to health. The wealthier citizens began to gather the rain water that fell on the roofs into water-tight cisterns, usually built in the ground, to preserve and cool the water for domestic purposes. As the wells became fouler, such cisterns gradually came into use among the middle classes, and finally even among the poorest, until a cistern for rain water became a necessary adjunct to a dwelling of any kind in Charleston. Early in the nineteenth century thoughtful minds began seriously to consider from what other source the city could obtain a general water supply of satisfactory quality. Various plans were proposed, one of which was to gather water from springs and convey it through wooden pipes, or even in carts, to the city. Such plans seemed insufficient, visionary or extravagant; at least nothing was done by the city authorities. About 1820 one of the citizens sank a well to a depth of 57 ft., which was far deeper than any in use up to that time. This well is believed to be in existence and in actual use up to this time, being located on the north side of Queen St., between King and Archdale. After that a number of wells were sunk to the 60-ft. stratum. In 1823 the city council determined to sink what they called an artesian well, or one of several hundred feet in depth. After many difficulties and repeated trials to sink artesian wells in various locations, and as many failures and intermittent work for 26 years, they obtained a well about 1,260 ft. deep; this one alone having cost over $30,000. This well was so small that a very insignificant quantity of water was obtained, but the head was sufficient to raise the water about 25 ft. above the surface of the ground. Nothing further of material value or importance was accomplished until about 1880, when a well nearly 2,000 ft. deep was sunk. Since that time two other wells were sunk, and until 1904 these artesian wells, one of which was the 1,260-ft. well, constituted the water supply of Charleston.

From 1876 the water-works was owned by private corporations. The service was seldom satisfactory, the vicissitudes of the water company being many, and even the interest on the bonded indebtedness was not always paid. The artesian wells yielded a maximum of about 1,700,000 gals. per 24 hours by pumping, and during the last few years the water was elevated by means of the air-lift to a pumping reservoir from which two 3,000,000-gal. compound condensing direct-acting pumps pumped the water into a stand-pipe 80 ft. high, which usually supplied the distribution system by gravity. The water was highly charged with soda, and therefore objectionable for manufacturing and culinary use, although highly prized by many for drinking and bathing purposes. The yield of the wells, however, was so deficient that for the last five or more years of their operation the general practice was to furnish full service and pressure during only portions of each day. This was so unsatisfactory that many of the inhabitants depended entirely upon rain water cisterns for their supply of water.

A typical analysis of the best of the artesian well waters is as follows, all in parts per 1,000,000:

Organic matter and water of crystallization	29.7	Chloride of sodium	195.0
Carbonate of iron	5.7	Carbonate of soda	810.0
Sulphate of lime	7.6	Nitrate of soda	9.5
Sulphate of magnesia	2.8	Silicate of soda	43.2
Chloride of magnesia	4.0	Silica	6.2
Total solids			1,113.9

The strata passed through consisted of about 430 ft. of tertiary formation; 250 ft. of shelly marl, and the balance down to 1,955 ft. cretaceous formations of various character.

The 1,260-ft. well previously mentioned (at Wentworth St.) is even at this day highly for its potable qualities. In 1,000,000, however, the total solids bicarbonate of soda, 1,220; sodium common salt, 1,180.

As before stated, the question of adequate water supply has been many years, and as far back as 1850 time the Edisto River has been many as the only source from which supply of water could be secured. In are even now many people in Charleston who are so biased in favor of the Edisto only possible supply of ample quantity quality that positive proof to the contrary would be unavailing. Various plans for obtaining the Edisto water at a cost within the possibilities of the estimated revenue obtainable were proposed, but none of these was found feasible. In 1880, when the city employed Mr. J. L. Ludlow, M. Am. Soc. C. E., to make surveys and determine the facts in the case. After surveys, preliminary plans and estimates of cost were made the city, whose finances were at that time such as to make it impossible to undertake the entire expenditure required by itself, invited reputable contractors to investigate the conditions and present some plan whereby the new water supply could be introduced either independently or in conjunction with the old Water Co. Up to this time no consideration had been given to any surface supply closer to the city than the Edisto River. It was then that the American Pipe Manufacturing Co. of Philadelphia became interested and sent the writer to investigate and report on the possibilities.

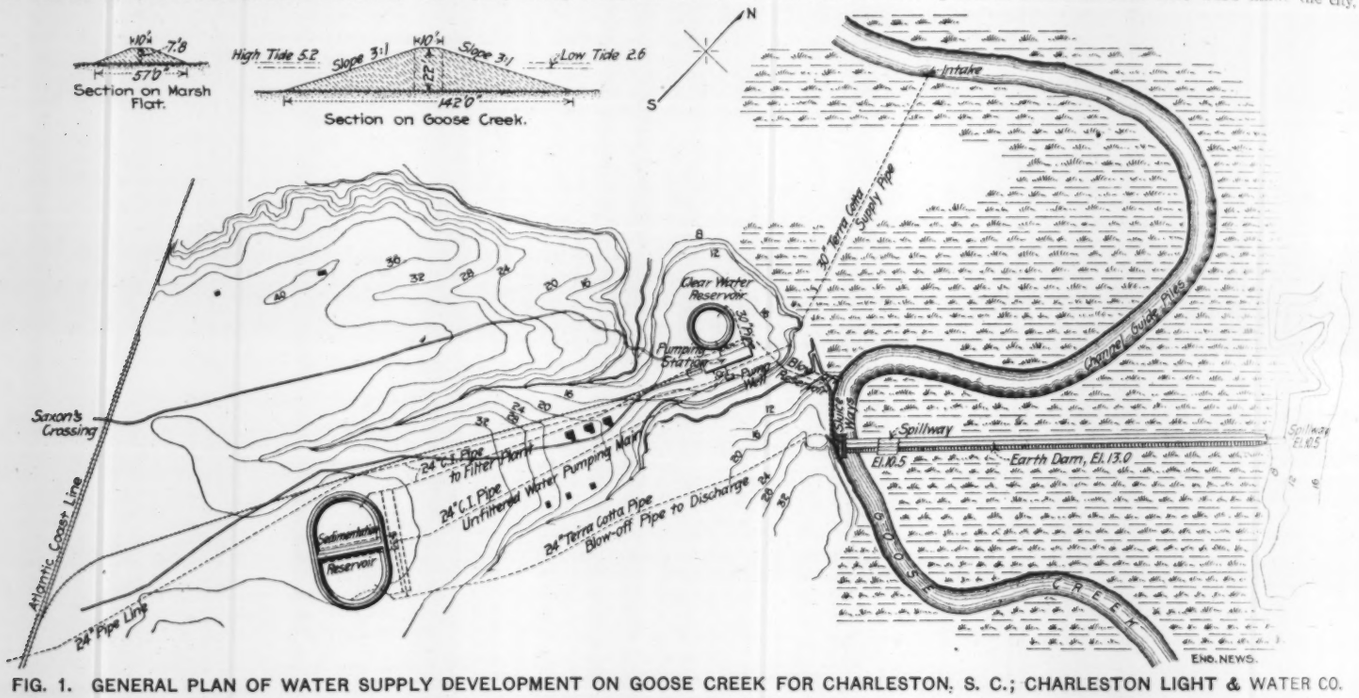


FIG. 1. GENERAL PLAN OF WATER SUPPLY DEVELOPMENT ON GOOSE CREEK FOR CHARLESTON, S. C.; CHARLESTON LIGHT & WATER CO.

It was found that the Edisto River, at Givham's Ferry, the nearest suitable point, was approximately 38 miles from the City Hall. The drainage area above Givham's Ferry is approximately 2,500 square miles; elevation of water surface, 36 ft. above tide datum; water highly colored by cypress swamps. To erect the necessary waterworks to afford a daily supply of 5,000,000 gals. was found to be prohibitive in cost, unless a cement-lined gravity ditch were substituted for the required 30-in. cast-iron, steel or wooden pipe. Even with a gravity ditch there would be required at least eight miles of pipe line or wooden flume, and the flume had serious objections of fire, depreciation, etc., and even a combined ditch and pipe line was not satisfactory to the trust companies. It was then determined that unless a nearer and less costly supply could be obtained the project would have to be abandoned.

*Condensed from a paper read before the Engineers' Club of Philadelphia. The paper in full will be published in the Proceedings of the Club.

†Chief Engineer, The American Pipe Mfg. Co., 112 Broad St., Philadelphia, Pa.

Fig. 2. Dam and Spillway, Looking West.

Fig. 3. West Spillway; Reservoir Beyond.

FIGS. 2 AND 3. VIEWS OF EARTH DAM ACROSS GOOSE CREEK, NEAR CHARLESTON, S. C.; CHARLESTON LIGHT & WATER CO.

Between the Edisto River and Charleston lies the watershed of the Ashley River. The drainage area above Bacon's Bridge, the upper limit of ordinary tide fluctuation, is about 90 square miles. The elevation of the water at this point is ordinarily about 6 ft. above tide datum. The water, like that of the Edisto River, is even higher in color, due to the extensive swamps on its watershed. From Bacon's Bridge to Charleston City Hall is approximately twenty-four miles. Investigation indicated the water supply to be ample, and in case of shortage, the expense of pumping the Edisto water over the divide into the Ashley drainage basin would have been small, and then if the level were raised 4 ft. at Bacon's Bridge, an immense quantity of water could be stored. However, the expense of going to the Ashley River was found to be prohibitive.

The next supply considered was that of Goose Creek, which rises some twenty-five miles northwest of Charleston and flows southeasterly into Cooper River. The drainage area above the Atlantic Coast Line Railroad crossing, the upper limit of tide fluctuation, is about thirty square miles, and the elevation of the water at this point is about 5 ft. above tide datum, and its character is entirely similar to that of the Ashley River. From this point to the Cooper River the stream is very tortuous, and it is bordered alternately on one side or the other by a gradually widening extent of treeless alluvial deposit, covered with a dense growth of reeds. Opposite Saxon's Crossing, five miles down stream from the Atlantic Coast Line Railroad crossing, the marshy flat is 2,500 ft. wide, and the stream proper is about 80 ft. wide, and has an extreme depth of 20 ft. On each side of the flat the soil is composed of sandy clay. The alluvial deposit in the flat is grayish black and of a peaty nature, highly charged with sulphur, and has an average depth of about 9 ft. at the site of the present dam, increasing to 20 ft. a mile up stream, and is underlaid with ten or more feet of fine sand lying on a marly deposit. At Saxon's Crossing the general elevation of this flat is about 5.2 ft. above tide, which fluctuates between 2.3 and 6.5 ft., although some extreme tides have risen to an elevation of 9 ft. above datum. The drainage area of Goose Creek is generally composed of pine forest growth, with swamps of various growth bordering each of the upper branches of the main stream. The population is very sparse, and a large proportion of the watershed is kept as a hunting preserve by the Otranto Club.

Sanitary analyses of the waters of the three streams are as follows:

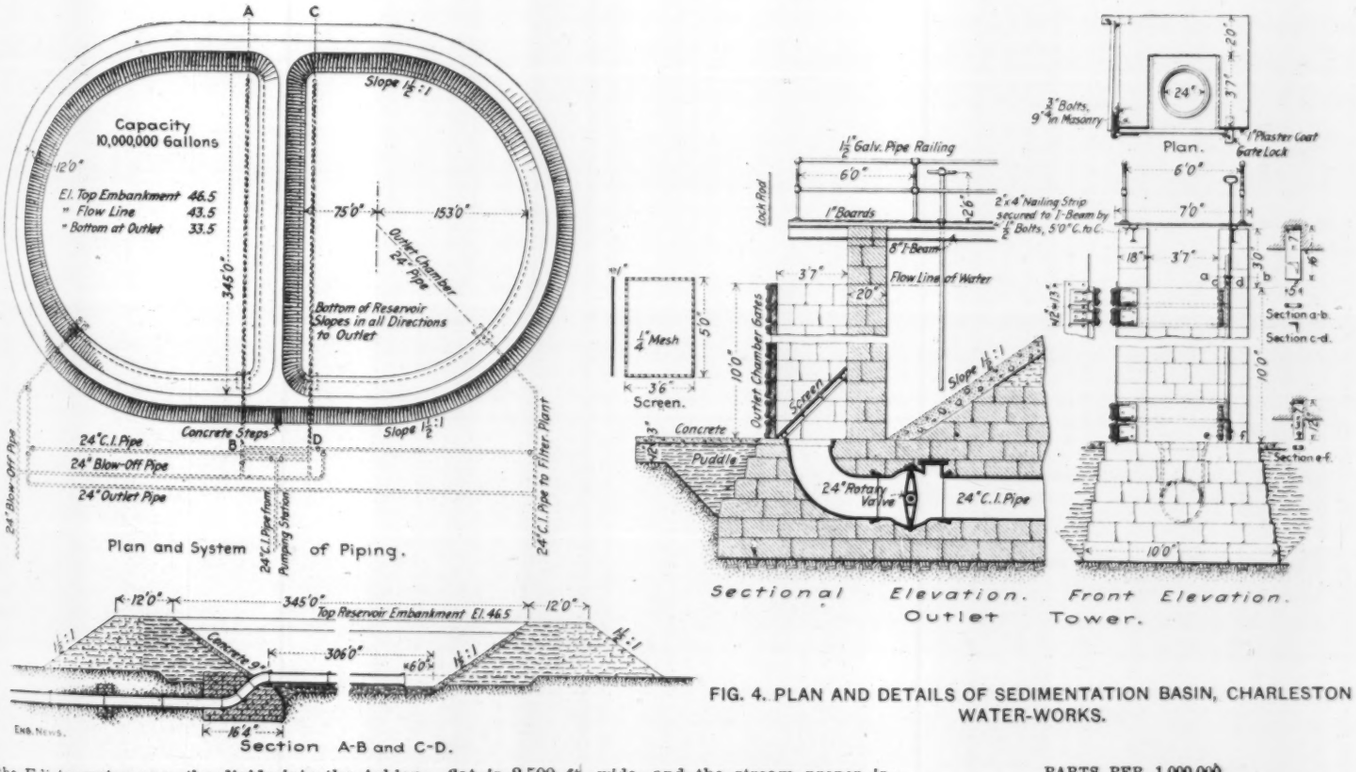


FIG. 4. PLAN AND DETAILS OF SEDIMENTATION BASIN, CHARLESTON WATER-WORKS.

PARTS PER 1,000,000.	Goose Creek.	Edisto River.	Ashley River.
Total solids (at 100°c)	80.0	52.0	70.2
Loss on ignition	35.9	25.8	34.7
Alkalinity in terms of calcium carbonate	20.1	10.0	15.3
Chlorine	10.0	5.0	8.9
Actual ammonia	0.026	0.024	0.018
Albuminoid ammonia	0.332	0.242	0.366
Nitrogen as nitrates	None	None	None
Nitrogen as nitrites	None	None	None

It will be seen from the analyses of the samples which were collected in February, 1901, that the

three waters are not essentially different, the Edisto being the best, although the hardest to filter. These waters resemble in quality and appearance those of the Dismal Swamp and Lake Drummond, Va., which are highly and universally prized as healthful by the people in that vicinity and by mariners.

On account of the practical advantages of the Goose Creek location, and the impossibility of obtaining either the Edisto or Ashley River supply directly by any known plan, it was finally decided to take the water supply from a point on Goose Creek opposite Saxon's Crossing on the Atlantic Coast Line Railroad. This point is approximately 12 miles from the city hall. A new company was formed, known as the Charleston Light & Water Co., which purchased the works of the old Water Co. and made a contract with the city, dated July 1, 1902, to supply it with water for a period of 30 years. Some of the local financiers, the Mercantile Trust & Deposit Co. of Baltimore, and the American Pipe Manufacturing Co., financed the new project, and the contract for designing and building the works was awarded to the American Pipe Manufacturing Co.* The works were begun the latter part of 1902 and substantially completed in the fall of 1903, and water was pumped into the city in January, 1904.

Referring to Fig. 1, it will be seen that a low earth dam has been built across Goose Creek where the stream hugs the south bank; the marsh is somewhat over 2,000 ft. in width. Views of the dam are shown by Figs. 2 and 3.

There are two spillways, each being 100 ft. wide and permitting a depth of 2½ ft. of water. There are also two sluiceways located at the south end of the dam, one being 5 ft. in width and the other 10 ft. in width. Each sluiceway is provided with two sets of gates, one to hold the up-stream water, and the other the possible high tides. The spillways are built of timber cribwork, with sheet piling extending down to solid material. The sluiceways are also built of timber, the quality being known as merchantable yellow pine. The material for the dam was taken from the south bank of the river, where excellent material, principally composed of clay, was obtained. This material was handled and deposited by means of dump cars running on a tram road for the entire length of the dam. The marsh proved to be so soft that it required at least three times the quantity of earth fill indicated by the theoretical section of the dam, and drill holes sunk into the center of the finished embankment showed the clay fill to extend down to a depth of about 22 ft., or some 15 ft. below the marsh level. This resulted in causing the marsh to rise up in waves, the outer slopes of which were at least 50 ft. away from the edge of the embankment on each side; these waves, however, nearly disappeared a year after the embankment was completed. The slopes of the embankment are protected from erosion by means of Knot grass, which, on account of wave action, did not prove effective for the up-stream slope, and hence it is proposed to cover this slope with a layer of 3-in. granite riprap.

The intake is built about 2,000 ft. up-stream from the dam. The elevation of the center of this intake pipe is zero according to our datum, which is 1.24 ft. below the Government datum at Charleston. The intake is composed of 30-in. extra heavy terra cotta pipe in 3-ft. lengths, having deep and corrugated bells. The bottom of the trench being soft, the pipes were protected from settling by means of piling. This intake was laid on a level grade and discharges into a suction well built close to the pumping station.

The reservoir holds, when full, 2,782,000,000 gallons, and covers an area of 2,090 acres. It backs the water for about ten miles above the dam. No attempt was made to clear the reservoir of organic matter, and even the standing timber was not removed. It was reasoned that as, in any case, it was prohibitive in cost, if not impossible, to get rid of at least 90% of this organic matter, that it was hardly worth while to remove that portion which was plainly visible to the eye, and hence entire dependence was placed upon the effect of coagulation, aeration, sedimentation and filtration to purify the water. In this respect experience has fully justified our conclusions.

The pumping station is built of brick, with cement floor, steel roof trusses and a[illegible] roof; the smoke stack was built by the Alpho[illegible]sto-dis Co. according to their regular des[illegible]. The pumping machinery consists of duplic[illegible] cross compound flywheel pumping engines, [illegible] having a capacity of 5,000,000 gals. per [illegible] hours, manufactured by the Snow Steam Pum[illegible]orks; also a triple expansion duplex pump[illegible]g a capacity of 3,000,000 gals. per 24 hou[illegible] the Worthington type; also two triple expa[illegible] low service duplex pumps of the Worthing[illegible] type, each having a capacity of 5,000,000 ga[illegible] per 24 hours. The three high service pumps [illegible] designed for a fire pressure of 125 lbs. p[illegible] in., and to run ordinarily under about 60 l[illegible] per sq. in.; the low service pumps run against [illegible] total head of about 33 ft., pumping from th[illegible] section well to the sedimentation basin. On [illegible] the Snow pumping engines developed a duty [illegible] 125,000,000 ft. lbs. per 1,000 lbs. of dry st[illegible] The Worthington high service 3,000,000-g[illegible] pump developed a duty of about 90,000,000, and [illegible] two low service pumps developed a duty of 7[illegible],000,000 ft. lbs. per 1,000 lbs. of dry steam.

There are three Stirling water tub[illegible] boilers, each having 2,012 sq. ft. of heating surf[illegible]. The condensers are all of the surface type. [illegible]here is installed a 20-HP. air compressor for [illegible]erating the water. Connected with the discharge main of the pumping engines there is set in the corner of the pumping room a steel pressure air tank 6 ft. in diameter and 12 ft. high, which is completely effective to eliminate the vibrations of water pressure due to the pulsations of the pumping machinery. For the purpose of charging with air, there is attached to this air tank an ordinary Westinghouse air compressor of the type used on locomotives; and connected with the top of the air chamber and the top of each of the discharge air chambers of the several pumping engines is a ¾-in. pipe, which enables all the air chambers to be easily charged with the requisite amount of air. This entire air cushion device we have always found to be invaluable in the operation of a pumping plant running by direct pressure, or where the discharge main is of a considerable length, as in this case, being about 63,000 ft. from the pumping station to the center of the city.

*112 North Broad St., Philadelphia, Pa.

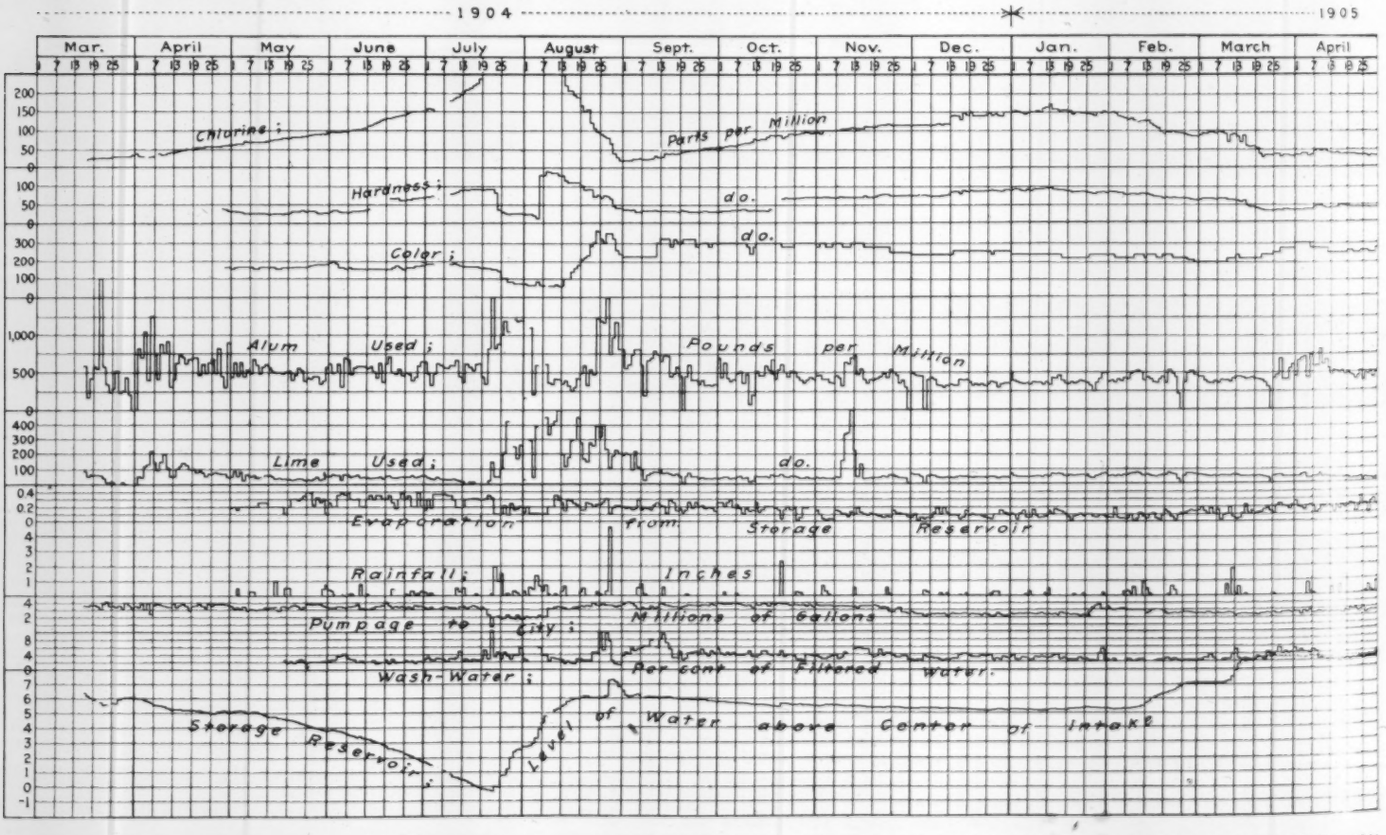


FIG. 5. DIAGRAM SHOWING COMPOSITION OF GOOSE CREEK RESERVOIR WATER, CHEMICALS USED FOR TREATMENT, EVAPORATION,

Each of the ...ping engines is equipped with a suction air ...ber of ample size.

The filter ...nt was built by the New York Continental ...ell Filtration Co., and has a capacity of 5,...00 gals. per 24 hours, consisting of ten cyp... tanks, operating platform, agitators, West... ontrollers, loss of head gages and usual access... s. The coagulent consists of sulphate of al... a, which is pumped into the discharge main ...om the low service pumps to the sedimentati... basin. A portion of the time the alkalinity of ... raw water is sufficient so that no other c... lent is required, but during the greater part ... the year the alkalinity runs below 20 parts ...r 1,000,000, when it is necessary to treat the ...w water with lime, and for this purpose a li... building with the necessary tank and accessor... is located close to the suction well and the lim... ater gravities into the intake pipe just before ... reaches the suction well. Usually it requires ...t three or four grains per gallon of sulphate ... alumina, and when required about one-third of ... grain of lime per gallon, the color of the raw ...ater being reduced from 230 to 15 parts per 1,...000. At least 75% of the purification of the ...ater is effected by the sedimentation basin. Water is pumped through a 24-in. main to one side of the sedimentation basin, and from the other side it passes through a second 24-in. main to and through the filters and into the opposite side of the clear water basin, and is drawn from the near side through the 36-in. suction pipe of the main pumping engines, and thence pumped through the discharge main to the city distribution. The sedimentation basin (Fig. 4) has a total capacity of 10,000,000 gals., and the clear water basin has a capacity of 1,000,000 gals. The elevation of the flow line of the sedimentation basin is 43.5, and the elevation of the flow line of the clear water basin is 17.0, the floor of the pumping station being the same level. The elevation of the top line of the filters is 33, and the elevation of the operating platform is 30. The elevation of the city streets is about three or four feet lower than the ground at the pumping station, so that ordinarily, when pumping at the usual rate of consumption, viz., about 400,000 gals. per 24 hours, the average pressure on the high service pumps is about 60 lbs. per sq. in., which maintains a pressure of about 55 lbs. in the center of the city. From the pumping station to the city there is a 24-in. pumping main, and the city contains about 43 miles of service mains, the sizes ranging from 6 to 24 ins. in diameter. The 24-in. pumping main is provided with automatic air valves on all summits, gate valves about a mile apart, and blow-off valves at depressions. All these are marked by means of square wooden posts, 6 ins. in diameter, painted white, extending about 2 ft. above the ground and having painted thereon the designation and the distance and direction thereto.

The hydraology of the territory along the coast in the vicinity of Charleston affords very unusual conditions. By an examination of the monthly rainfall, especially for the driest years, it will be seen that there are distinctly two dry seasons per year, one commencing usually the latter part of February and ending some time in July, and the other commencing the latter part of August and ending some time in December or January. In fact, the dry season would last from the latter part of August clear through the winter's season until July if it were not for the low temperature of the months of January and February; while the rainfall is not high for these months, it is nearly always higher than the evaporation, or losses, for the same months.

While the annual rainfall averages about 52 ins., the rainfall for a low five-year period would not exceed 37 ins. As the temperature is high, especially during the months from April to October, when it is constantly warm, with practically no intermission, the larger rainfall for the months of July and August does not produce the beneficial effect it would two or three hundred miles farther north, where the temperature is lower.

In Charleston and vicinity the rainfall has been kept in a way for about 180 years, but the Government observations date only back to 1871. The annual rainfall appears to be decreasing. This fact is so marked as to warrant the suspicion that some natural phenomenon was responsible for the result. The great earthquake, which so seriously injured the city, occurred in the summer of 1886, and while this was a year of unusually low rainfall, viz., 35.4 ins., the diagram shows that this was not the time when the annual rainfall began to decrease in a more or less regular manner. The chances are that this cycle of decreasing rainfall has reached the low point of the curve. The years commencing in 1900 and dating up to the present time are the lowest on record, the average being 38.23 ins. per year for six years. This is a most unprecedented condition for a territory where the average rainfall is 52 ins. per year.

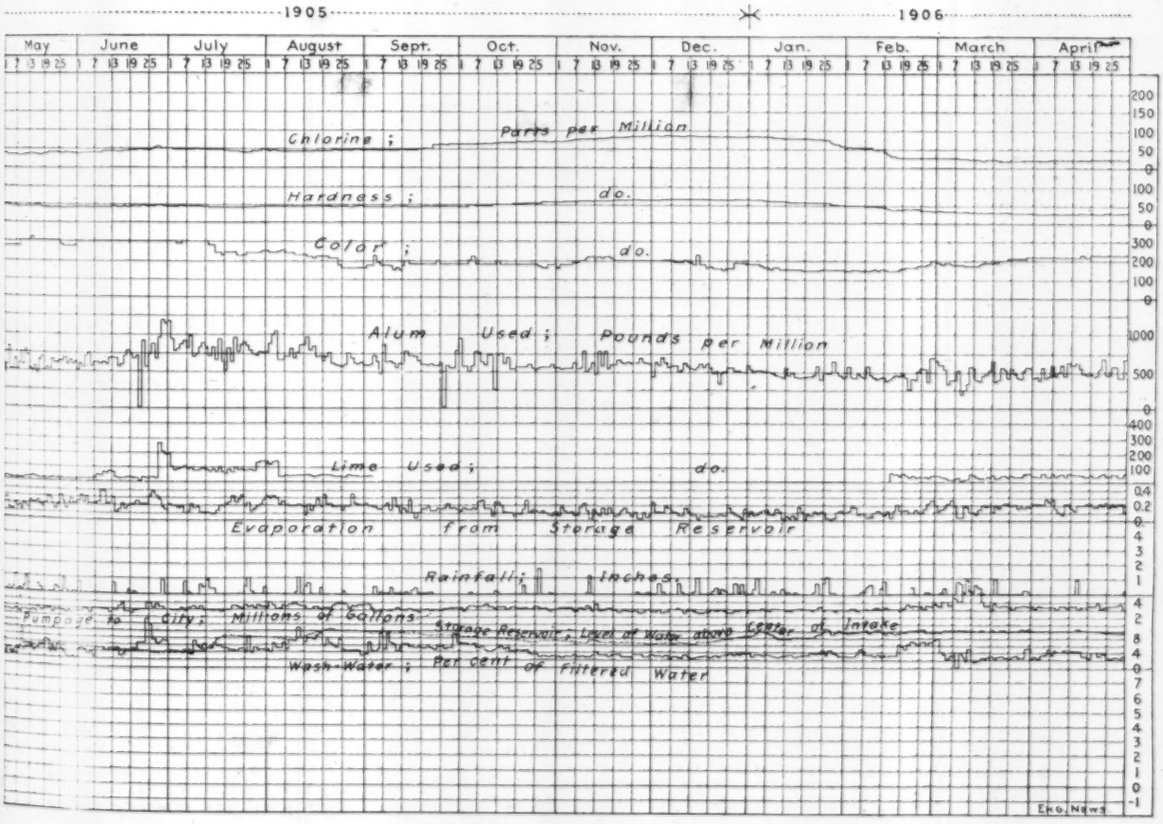
The annual evaporation from water surface is 37% higher than that given for this territory in the current publications, and 76% higher than that given for the three hottest months, viz., May, June and July. In the following table a comparison is shown between the published figures and those actually observed.

INCHES OF EVAPORATION.

	Published figures.	Observations on the water surface at Goose Creek.
January	2.5	2.57
February	2.5	2.26
March	3.5	4.36
April	3.7	5.55
May	3.9	7.08
June	4.4	8.65
July	4.5	6.77
August	4.8	6.22
September	4.2	5.79
October	4.0	5.22
November	3.2	2.66
December	2.5	2.69
	43.70	59.82

The observed figures are for the year 1904, from May to December, inclusive, and for 1905, from January to April, inclusive. This comparison shows conclusively that no reliance can be placed on calculations based on the results obtained by the wet and dry bulb thermometer, which I believe is the method on which the published figures are based. Since the spring of 1904 the evaporation from the water surface of the dam has been observed daily, the figures being shown on the diagram, Fig. 5.

With the utmost storage capable of being developed on the Goose Creek drainage area of 49 sq. miles, it is possible to obtain in the driest season a yield of 0.22 cu. ft. per sec., or about 140,000 gals. per 24 hours per sq. mile. On the Croton (N. Y.) or Sudbury (Mass.) watersheds it is pos-



RAINFALL PUMPAGE, FILTER WASH WATER, AND LEVEL OF WATER IN RESERVOIR; CHARLESTON WATER-WORKS.

sible, with maximum storage, to obtain and depend upon at least 0.9 cu. ft. per sec., or 600,000 gals. per 24 hours per sq. mile; and even at Norfolk, Va., where the topographical conditions are entirely similar to, although not as favorable as, those of Goose Creek, it is possible to obtain as much as that at Sudbury or Croton. In this table, which shows the quantity of water obtainable with various amounts of storage, the results are based on the dry period from 1900 to 1904, which is probably the most extreme drought ever experienced in that country.

When the works were first put into operation in January, 1904, the chlorine in the reservoir was about 4,000 parts per 1,000,000, and with the closing of the dam this rapidly diminished to about 800 parts per 1,000,000, and in order to reduce the chlorine to the requirements of the contract, large centrifugal pumps were set to work, pumping the water out of the reservoir so as to displace the saline water with fresh water from the upper portion of the watershed. By the latter part of February the chlorine was reduced to 85 parts per 1,000,000. It was then an extreme dry season began, with very little storage in the dam, and by the end of July the level of the water had reached the top of the intake pipes, where it remained, however, for only a day or so, when the summer rains rapidly filled the reservoir, since which time no shortage of water has been experienced. During this period of low water the quality of the water was by no means good; the total solids, hardness and chlorine averaging high. Since that time, however, the filtered water has been very satisfactory, clear and odorless, but during the summer of 1905 the water developed a pronounced odor, and after a thorough investigation it was found that the raw water was entirely devoid of dissolved oxygen. Air was then snifted into the suction of the low service pumps, and within three or four days the water became again of good quality and thoroughly satisfactory. An air compressor was then installed, so that the water could be aerated satisfactorily at all times. No further trouble has been experienced.

A typical analysis of Goose Creek filtered water is as follows:

PARTS PER 1,000,000.

Total solids	123.000
Loss on ignition	33.000
Hardness	33.860
Alkalinity	6.000
Carbon dioxide CO_2	5.000
Carbonates CO_3	3.06
Chlorine Cl	25.000
Nitrates NO_3	.050
Sulphurous acid SO_3	36,810
Silica SiO_2	1.580
Aluminum oxide Al_2O_3	1.020
Iron oxide Fe_2O_3	.710
Calcium oxide CaO	16.910
Magnesium oxide MgO	.602
Sodium oxide Na_2O	21.330
Potassium oxide K_2O	.870

The contract requirements in regard to the water supply are substantially as follows: Guaranteed supply of 5,000,000 gals. per 24 hours; ability to pump at the rate of 8,000,000 gals. per 24 hours in case of emergency; water to be good and potable and free from objectionable odor and taste, and suitable for manufacturing and laundry use; the filtered water to contain per million parts not more than 85 parts of chlorine, 75 parts of total solids, exclusive of common salt; 45 parts of total hardness. The filters shall remove at least 85% of the albuminoid ammonia in suspension; at least 85% of the color by the Platinum Cobalt Standard; 97% of the bacteria when the number in the raw water is over 3,000 per c.c., and all but 100 when the number in the raw water is less than 3,000 per c.c. Bacteriological analyses of the filtered water have been frequently taken and the filtered water at the pumping station usually contains less than 50 bacteria per c.c., while the raw water varies from 350 to 1,000, the average being about 500 bacteria per c.c.

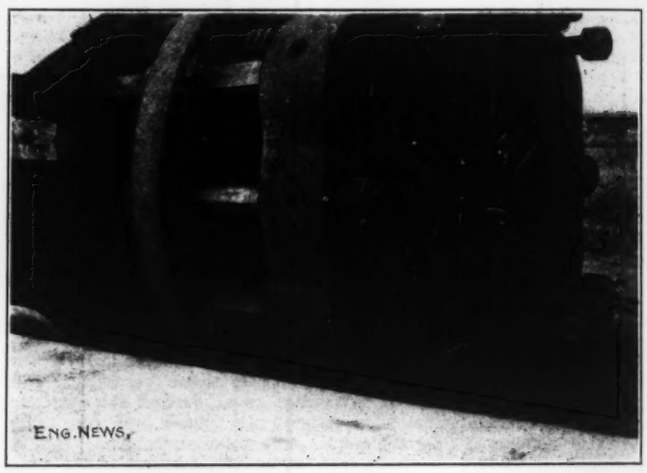
It will thus be seen that whereas the problem of compliance with the city contract was by no means easy, the results obtained show that it has been solved beyond question. [The diagram, Fig. 5, shows the composition of the water of Goose Creek, and gives a variety of other information bearing upon the water supply and its treatment.—Ed.]

In calculating the stream flow for years other than those for which we have actual records, the general method adopted by Mr. C. C. Vermeule, M. Am. Soc. C. E., for the New Jersey streams, has been adopted, the formulas, however, being deduced from the actual conditions for the periods observed.

A NEW METHOD OF PUMPING HEAVY CRUDE FUEL OIL OR OTHER THICK VISCOUS FLUID.

By John D. Isaacs.*

The crude oil product of most of the California fields is a very heavy, thick and viscous fluid with an asphalt base. The entire product of the Kern River fields, near Bakersfield, is particularly heavy, its density averaging about 14° Baume. Up to the present time, this oil has been transported from the fields in cars. Although attempts have been made to facilitate its movement by long pipe lines, these trials have met with little success, as it was found necessary to use very high pumping pressures, necessitating expensive pipe and powerful pumping plants placed so close together that operating expenses became too high for practical economy, and moreover with such a plant the delivery was very small.



RIFLING MACHINE FOR 5 TO 9 INS. STANDARD PIPE.

Various attempts were made to overcome these difficulties, the most important being the heating of the oil. This was a decided help in short pipe lines, but a temperature sufficient to be effective for long distance pumping caused the disintegration of the oil and the deposit of asphaltine, called by the oil men "Carbonizing," thus clogging the line. Water was also introduced with the oil, but 30% of water was needed to materially improve the results and the surging of the mixture through the line soon caused an emulsion of the oil and water, which is very difficult and expensive to separate, necessitating heating the oil to 180° F. The mixing of the lighter oils with the heavy oils has made it possible to pump the mixture, but in the fields where only the heavy oils are obtained, this necessitates the pumping of the light oils to such fields from long distances, and as the mixing of the oils causes a loss in the value of the light oils, which have a market value much higher than the heavy fuel oils, the process is very expensive.

A new process has been adopted by the Southern Pacific Company which has led to the construction of a "Rifled Pipe Line." The method is to rifle the pipe, giving it an interior appearance similar to that of a rifle barrel, while a small percentage of water is pumped with the oil. The rifling of the pipe causes the entire liquid mass to whirl, and as the water is heavier than the oil it is thrown to the exterior of the mass, thus causing the envelopment of the oil with a thin shell or film of water. This forms a water lubrication between the oil and the pipe, greatly reducing the friction and allowing a core of oil to glide through the pipe [illegible] fully.

EXPERIMENTS.

When this principle was discovered [illegible] the first experiment was made with a small [illegible] lead pipe. In the process of drawing ordinary pipe the interior surface is slightly scored longitudinal lines. The pipe was first [illegible] as received and friction co-efficients determined; it was then twisted by hand, causing longitudinal scorings to become helical, which was sufficient to cause a rotation of the water when passed through the pipe. [illegible] experiments made with this rifled lead pipe [illegible] proved the soundness of the principle and led to an experiment on a larger and more practical scale. One-half mile of 3-in. standard pipe was used in the next experiment, which was performed by the Southern Pacific Company at West Oakland. The pipe was first rifled by the insertion of helical wires. This was accomplished by simply drawing tempered steel [illegible] from a coil through the pipe in lengths of [illegible] ft. at one time, the spring of the wire causing it to cling closely to the sides of the pipe, forming a helix. This pipe was then laid and subjected to an exhaustive experimental operation with heavy Kern oil. The best results were obtained by pumping about 10% water with the oil. A flow was obtained many times that obtained by pumping pure oil, or oil and water, through an ordinary plain pipe. The 3-in. line was then rifled, by passing the pipe through a series of rollers, to a pitch of 1.5 with the line of the pipe. (See description of rifling machine which follows.) Experiments on these lines gave even better results and lower co-efficients than those from the lead pipe and justified the construction of a practical rifled pipe line for transporting oil commercially.

PIPE LINE.

A rifled pipe line was finally constructed, 31.17 miles long, between Volcan, a point located centrally in the oil fields and on the Southern Pacific Company's railroad, and Delano, another station northward on the same railroad at an elevation of 120 ft. below Volcan. The pipe used was standard 8-in. line pipe, weighing 28.2 lbs. per ft., fitted with recessed line couplings and tested to 1,200 lbs. per sq. in. The pipe was laid in a ditch to a depth of about 2 ft. and screwed together by four pair of 8-in. lay tongs handled by 16 men. The ditch was dug about 18 ins. wide and the pipe laid zigzag within the easy elastic bending of the pipe to provide for expansion by heat. In the vertical plane, the pipe was also laid with a vertical zigzag or wave of about 400 ft. in length or shorter, the depth of these waves being about the diameter of the pipe, so as to form traps at 400 ft. intervals. The object of these traps is to accumulate water at frequent intervals when the line is shut down, thus preventing the formation of a long plug of solid oil, and facilitating the restarting of the line.

The line was first tested with water and all breaks and leaks repaired until the entire line held 1,000 lbs. pressure. The line was next subjected to a continuous operating test, lasting 24 days. During this run an average of over 14,000 bbls. net oil, in 24 hrs., was obtained for the entire run at an initial pressure of 800 lbs. per sq. in. For several hours at various parts of the test over 675 bbls. of net oil per hour was pumped at 800 lbs. The oil furnished was exceptionally heavy and had stood for a long period in an earthen storage reservoir so that much

*Consulting Engineer of the Harriman Lines, Oakland, Cal.

of its light constituents had evaporated. The temperature of the oil was below 60° F. when received at Delano, and in no case was over 75° F. when received at the pumping station, averaging much lower. Experiments show that the maximum flow of oil was obtained when about 10% of water was used. At the end of the line, the water and oil were found entirely separate and when run into the settling tanks the water was easily tapped off, leaving only about 1% in the oil shipped. From Delano the oil was shipped away in cars for commercial use.

PUMPING STATION.

The pumping station consists of three 200-HP. boilers of the return tubular type fitted with water heater, duplicate feed pumps and pressure burners. The main pump is a compound duplex steam pump, 25 and 42 in. steam cylinders with 9½-in. oil plungers with 36-in. stroke. The auxiliary water pump is a duplex plunger steam pump, 16-in. steam cylinders, 5-in. plungers and 12-in. stroke. The oil supply tank is placed 30 ft. above the oil pump and a 27-in. suction pipe about 100 ft. long is used, thereby insuring an ample supply for this pump. The water is injected by means of a special injection nozzle. A piece of 7-in. well casing is introduced inside the 8-in. pipe; oil passes through the inner pipe and water is introduced through the annular space between the two pipes, both thus starting off in their proper relative position. A short baffle, or twisted plate, is placed in the inner tube at this point to give the oil an initial whirl.

MANNER OF RIFLING PIPE.

The pipe was "Rifled" in the following manner by the machine shown in the accompanying sketch: The large discs "A" and "B" carry six rollers, each mounted in roller fork bearings. The central disc "C" is a floating disc, to which are attached wedges "W," these wedges tapering outward on both sides of the disc, one wedge being opposite each roller fork, and engaging therewith. When the discs "A," "B" and "C" are apart, the rollers are open wide enough to allow a pipe coupling to pass freely between them. By means of the pulling rods "P" operated by the lever "L" the three discs are drawn together to any limit set by the adjustable stud bolts "S." This drawing together of the three discs causes the wedges to thrust the roller forks toward a common center, that is, indent them into the pipe to any desired depth. The rollers were set to a pitch of about 1:5 with the line of the pipe. The discs are so spaced that each roller in disc "A" lines up with the one just to the right in disc "B," so that when the pipe is drawn through it rotates 1/8 of a turn between the two discs. Thus, for one turn of the rifling in 10 ft. of pipe, the discs would be 1/8 of 10 ft. apart in the closed position, or 20 ins. The circumference of an 8-in. pipe is about 25 ins., so that the pitch of rollers to correspond to one turn of rifling in 10 ft. would be as 25:120. The male thread of each length of pipe was fitted with a pulling plug, having an air vent, and a testing plug on the coupling end by which water was introduced. The pipe was filled with water, the pressure raised to 1,200 lbs. and then released. If the pipe stood the test satisfactorily, it was placed in the rifling machine, the rollers being closed just behind the pulling plug so as to indent the pipe to a depth of 3/32 in. By means of a hoisting engine and a pair of triple blocks, reeved with a 7/8-in. steel cable, the pipe was drawn through the machine, the rollers describing six helical paths around the pipe, one complete turn in each 10 ft. The result was a pipe spirally indented and having the appearance of being rifled when looked into at one end. The rollers were then opened, the pipe drawn out, and subjected to 1,200 lbs. water test. During the operation of the machine, the rollers were flooded with lubricating oil.

RESULTS OF TESTS.

The following formula was used in determining the value of "K":

$$p = \frac{Kv^2}{d}$$

p = Fall in pressure per 100 ft.
d = Diameter of pipe in inches.
V = Velocity in feet per second.
K = Constant of flow.

This formula does not hold good for all cases and is only used for the purpose of comparing the flow of oil and water through the same pipe line. The values of "K" thus obtained are as follows:

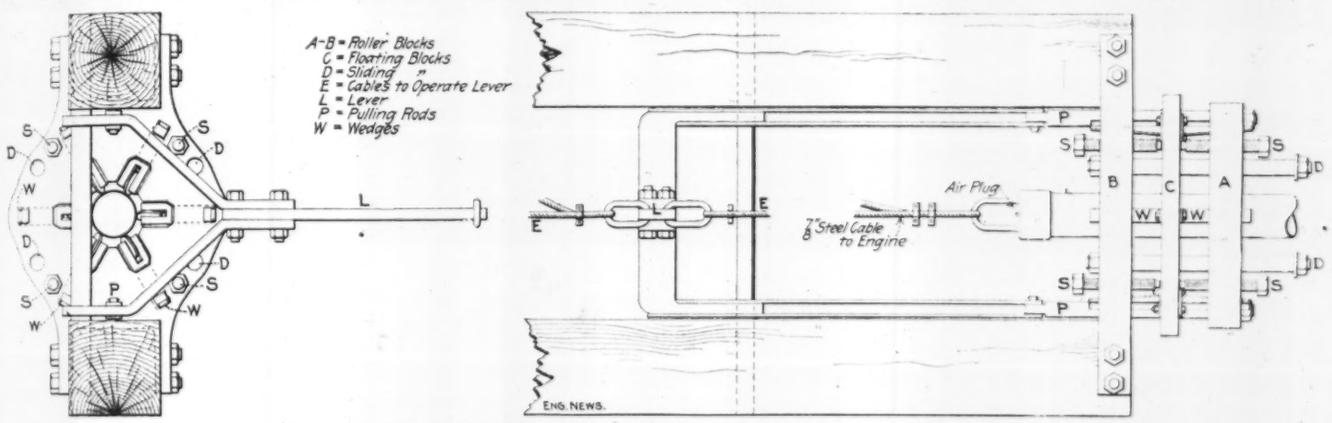
8-in. plain pipe, not rifled.	
Straight oil, no water, average	K = 70.00
90% oil, 10% water, average	K = 41.00
8-in. rifled pipe.	
90% oil, 10% water, average	K = 00.49
" " " " best result	K = 00.37
3-in. plain pipe, not rifled.	
Straight oil, no water, average	K = 148.00
3-in. rifled pipe.	
90% oil, 10% water, average	K = 00.33
" " " " best result	K = 00.25
All above pipes.	
Straight water, no oil, average	K = 00.18

The results show that the rifled process increases the flow of net oil through a long pipe line eight to ten times that of the plain pipe under similar conditions as to diameter of pipe, pressure, etc. While the values of "K" for the 8-in. pipe are considerably larger than those for the 3-in. pipe for the rifled process of pumping, the faults developed in the Volcan-Delano line indicate plainly that in future lines, the rifling may be so modified as to bring the value of "K" down to at least that shown by the 3-in. line.

Among the anticipated difficulties which did not develop were:

(1) The difficulty of starting after stopping. (2) Emulsification of water in the oil. (3) Reversal of density under pressure of the oil and water. This was at one time regarded as a probable serious obstacle due to the fact that the oil is quite compressible (which, by the way, has considerable bearing on the facility in starting). It was surmised that possibly under pressure with an elastic oil approximating so closely to the density of water, that their densities might be reversed, in which case the application of the theory would fail in practice. Experiments were made on this phase of the matter by filling a pipe with oil upon a layer of water, the relative percentage being about that which was expected to be used in pumping. The pressure was then raised to various points and the pipe reversed a while so as to see whether from a practical experiment such an obstacle actually occurred. From these experiments and theoretical considerations, it was determined that the density of the oil became the same as that of the water at pressures very greatly higher than those that would likely be used for such purpose. (4) The possibility was anticipated that the joints in the pipe (when the ends are screwed into the couplings, there is left a space of about ¼ in. between the two ends) might produce a turbulent flow and neutralize or destroy the separating effect of the centrifugal action upon the mass of oil and water. In practice it was found that such action did not take place and that this annular space was filled with a more or less permanent washer of water, and the flow was still as definitely helicodial as if the annular space had been filled as it was in some experiments with a lead washer carefully scraped out to the diameter of the pipe.

The above conclusions are not altogether surmised from results, but have been clearly visible by the introduction at intervals in the 3-in. half mile pipe line, laid at Oakland, of sections of heavy glass pipe through which the action in starting, rotating, etc., was clearly observable.



PLAN AND END ELEVATION OF RIFLING MACHINE FOR STANDARD 8-IN. PIPE.

This system of pumping fluids is the joint invention of the writer and Mr. Buckner Speed, Superintendent of Pipe Lines, Southern Pacific Co., and was developed after many attempts to accomplish the same result by other methods.

CHAIRMAN SHONTS ON THE TYPE OF CANAL TO BE BUILT AT PANAMA.*

The present Commission regards the Panama Canal as the property of the United States, with the citizens of the United States as the stockholders.

The present Commission believes that the type of canal the people of this country want is the one which will provide adequate and safe passage for the largest vessels on the seas, and which can be constructed in the quickest time and at the least cost. It has therefore recommended the construction of an 85-ft. level lock canal, for the reasons that, first, in its judgment, it can be completed for about half the cost, and in half the time, of the so-called sea-level canal; second, because it will be adequate for all the commerce which can reasonably be expected to seek that route during the next one hundred years; third, because if the tonnage should increase beyond such expectation, it can be enlarged more cheaply and more quickly than the so-called sea-level canal; fourth, because, from the operating point of view, large ships can be put through more safely and more quickly than through the sea-level; fifth, because when the interest on the difference in cost of construction is added to the cost of operating, the saving to the Government every year will be $2,340,000.

The so-called sea-level canal is a deep, narrow, tortuous gorge, through which large ships cannot pass, even according to the estimate of the men who recommend that type of canal, at a greater speed than four miles an hour, and which will contain at times, according to the same authority, a current in one direction of 2.6 miles an hour. I venture to say that no large ship, occupying, as large ships will, 40% of the prism through which it will pass, can navigate at that speed, with that current, safely, under its own steam.

The lock canal, on the other hand, as recommended

*Extract from an address before the Chamber of Commerce of Atlanta, Ga., on May 30.

by the minority of the Consulting Board and indorsed by our Commission, will have 35 miles of free lake navigation, so that the difference in time of putting large ships through the locks will be more than offset by their speed through the lake portion of their trip, which is more than two-thirds of the entire length of the canal.

By simply raising the sides of our spillways and increasing the depth of our locks, we can increase the depth of water in the canal so as to take care of still larger vessels than the 40-ft. ships provided for in our present estimate; whereas, in a sea-level canal, you would have to excavate the whole distance for every foot of increase made in depth.

NOTES FROM THE ENGINEERING SCHOOLS

ARMOUR INSTITUTE OF TECHNOLOGY.—The institute announces the graduation, on June 14, of its first class of students in the department of Fire Protection Engineering. This is believed to be the only department of its kind offering a full four-years' course in this branch of engineering. The specialized laboratory work is done through the cooperation of the Underwriters Laboratories, at Chicago.

A TROLLEY ACCIDENT at East Providence, R. I., on June 3, resulted in the death of eleven and the injury of 75 persons. A car loaded with about 100 excursionists returning at midnight from a neighboring shore resort, with a clear track and at high speed, struck a sharp curve at the foot of a hill a quarter of a mile long, and the body was torn free of the trucks and fell on its side. Six of the passengers were instantly killed and five more were so badly injured that they died on the way to the hospital. Of the 75 injured only one was dangerously hurt. It is stated that the motorman was a stranger to the line and did not become aware of the curve until it was too late to slacken speed materially. The local coroner and the railway company are both conducting investigations.

THE BILL FOR THE PRESERVATION OF NIAGARA Falls has passed the House of Representatives as reported from the Committee on Rivers and Harbors. The measure provides that the Secretary of War shall be authorized to grant permits for the diversion of water in the United States from the Niagara River to companies, individuals and corporations which are now actually producing power from the river; also for the transmission of power from Canada to companies legally authorized therefor, but only to the amount now actually in use. The Secretary of War, however, may grant revocable permits from time to time for the diversion of additional water to such amount as, in connection with the amount diverted from the Canadian side, shall not injure or interfere with the navigability of the river and its integrity and proper volume as a boundary or the scenic grandeur of the falls. The amount of power which the bill permits to be transmitted into the United States from Canada is fixed at 160,000 HP., provided that the Secretary of War may issue revocable permits for the transmission of additional electrical power so generated in Canada, but in no event shall the total amount together with what may be generated and used in Canada exceed 350,000 HP. This amount is fixed as a limitation, and it is not to be construed as directing the Secretary of War to issue permits to this extent. The act is to remain in effect for three years, and the President is requested to open negotiations with Great Britain for the purpose of effectually providing by treaty for regulation and control of the waters so as to preserve the scenic beauty of the falls and the rapids to the river.

THE WATER SUPPLY AND FIRE PROTECTION of Charleston, S. C., has been reported on by the National Board of Fire Underwriters' Committee of Twenty (135 William St., New York City) It is recommended that the water-works be improved by the addition of a 5,000,000-gal. high-pressure pump; that a new 24-in. force main be laid; that systematic records of consumption be kept; that the distribution system be reinforced by 24 to 12-in. mains, and that various minor improvements, such as are suggested in practically all of these underwriter reports, be made. Still more extensive improvements are advised as regards the fire, building and electricity departments of the city. Narrow streets and inadequate window protection should be remedied at once, and automatic sprinklers should be provided in such buildings as might serve as conflagration breeders.

THE ORE DOCKS ON THE GREAT LAKES, that is, docks for shipping ore, are 27 in number, and particulars of them have been tabulated by Mr. R. Angst, Chief Engineer of the Duluth & Iron Range Ry. There are 7 at Escanaba, Mich.; 5 at Two Harbors, Minn.; 4 at Duluth, Minn.; 4 at Marquette, Mich.; 3 at Ashland, Wis.; 3 at Superior, Wis., and 1 at Michipicoten, Ont. These are owned by nine railways, and have a total storage capacity of about 1,281,100 tons. A list of the dimensions of 25 of these docks was given in our issue of July 30, 1903.

MOTOR WAGONS FOR REFUSE COLLECTION have been found more expensive than horse haulage at Cardiff, England. The city has four motor wagons in use for this purpose, hauling trail wagons, and Mr. Wm. Harpur, City Engineer, recently reported that the motor wagon collection is 40% more costly than the horse collection.

PERSONALS.

Mr. Omar A. Turney, formerly Deputy City Engineer of Phoenix, Ariz., has been appointed City Engineer.

Mr. W. P. Mason has been appointed Consulting Engineer for the new city water-works plant of Newark, Ohio.

Mr. W. F. H. Finke has been appointed Tie and Timber Agent of the Southern Ry., with office at 1300 Pennsylvania Ave., Washington, D. C.

Mr. Adrian H. Joline has been elected Chairman of the Board of Directors of the Missouri, Kansas & Texas Railway Co., to succeed Henry C. Rouse, deceased.

Mr. W. J. Backes has been appointed Chief Engineer of the Central New England Ry., with headquarters at Hartford, Conn., to succeed Mr. W. B. Chapin, resigned.

Mr. John Murphy, formerly of the Ottawa Electric Co., has been appointed Superintendent Electrician to the Department of Railways and Canals and also to the Railway Commission.

Mr. R. G. Hengst, Assistant Chief Engineer, at New Castle, Pa., of the Western Allegheny Railroad Co., has resigned his position to enter the contracting business with Mr. F. A. Maselli, of Rochester, N. Y.

Mr. E. W. Lewis, M. Am. Soc. C. E., has resigned as Division Engineer of the Portland & Seattle Ry., at White Salmon, Wash., to accept a position with the New York, New Haven & Hartford R. R.

Mr. Sidney A. Reeve, Professor of Steam Engineering at Worcester Polytechnic Institute for the past ten years, will sever his connection with the Institute July 1 and open offices at Worcester, Mass., as consulting engineer.

Mr. Edwin H. Smythe has opened offices at 738 Monadnock Building, Chicago, Ill., as a Patent Expert. He will give particular attention to cases involving telephone patents, although cases connected with electrical patents in general will receive attention.

Mr. S. O. Ochs, formerly associated with the Stanley Electrical Instrument Co., Great Barrington, Mass., is now representing the Fort Wayne Electrical Works, of Fort Wayne, Ind., in the New England States, with headquarters at Boston.

Mr. O. E. Shields, of Pittsburg, has been appointed Manager of the Railroad Water Softening Department of the Pittsburg Filter Manufacturing Co. He assumed management of this department June 1, and will devote his time exclusively to railroad work.

Mr. Frederick C. R. Spence has severed his connection with the Stanley Instrument Co., Great Barrington, Mass., to become Special Representative of the Fort Wayne Electrical Works, of Fort Wayne, Ind., for the sale of meters. His headquarters are at Fort Wayne.

Mr. C. H. Meeds, Assistant City Engineer of Cincinnati, O., in charge of intercepting sewers, has resigned to become Engineer and Superintendent for the Procter & Gamble Co., in the construction of their New York plant on Staten Island. His resignation took effect June 1.

The following changes have taken place in the Reclamation Service: Mr. Earle E. Knight, Mr. Rollin Ritter, Mr. John C. Holmes have been appointed Assistant Engineers and assigned to duty on the Huntley Project, Mont.; Mr. P. M. Fogg has been appointed Assistant Engineer and assigned to the Lower Yellowstone Project; Mr. John B. Siobo has been appointed Assistant Engineer and assigned to duty on the Sun River Project.

The degree of Doctor of Engineering was conferred upon Mr. Earnst Koerting, for his scientific researches and discoveries in gas engines and other branches of engineering, by the Koeniglich Preussische Technische Hochschule, of Hanover, Germany, at the celebration of its 75th anniversary. Mr. Koerting's home is at Pegli, Italy, but at present he is visiting the United States, being interested in the De La Vergne Machine Co., of New York City; the Schutte-Koerting Co., of Philadelphia, Pa., as well as the firm of Gebr. Koerting, A. G. Koertingsdorf, Hanover, Germany.

Obituary.

William M. Hogencamp, a Builder and Contractor of New York City, died May 30, aged 57 years.

Edgar K. Ray, a prominent New England street railway promoter and head of the Ray system of street railways of Rhode Island and southern Massachusetts, died at his home at Elms Farms, Mass., May 30. He had been an invalid for nearly two years.

George M. Root died at Glen Ridge, N. J., M... at the advanced age of 86 years. He was a gra... of Columbia College and had been engaged in ci... neering for many years on Staten Island, N. Y., ... was an authority on land and water boundaries.

John C. Nulsen, President of the Missouri ... Iron Co., died at his home in St. Louis, Mo., Jun... an attack of dropsy. Mr. Nulsen was born ... 1824, at Goettingen, Hanover, removing to th... States in 1844 and settling in St. Louis in 1845.

Major Robert B. Gorsuch, Hon. M. Am. So... Chief Engineer of the Mexican International R... recently at Mexico City, Mexico, death being ... paralysis. Major Gorsuch was born at Brookly... about 80 years ago and was elected the first ... and treasurer of the American Society of Civil E... at the time of its formation in November, 185... he resigned from the society and was made an ... member in January, 1905. He was the first of th... can colony to engage in engineering work in ... having made the first surveys for the Mexican ... Cruz Ry., the beginning of railways in the ... Americas. A portrait and biographical sketch of Major Gorsuch was published in Eng. News, Vol. I., ..., p. 386.

ENGINEERING SOCIETIES.

COMING MEETINGS.

MASTER CAR BUILDERS' ASSOCIATION.
June 13. Annual convention at Atlantic City, N. J. Secy., J. W. Taylor, 658 Rookery, Chicago, Ill.

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.
June 18. Annual convention at Atlantic City, N. J. Secy., J. W. Taylor, Old Colony Bldg., Chicago, Ill.

AMERICAN SOCIETY FOR TESTING MATERIALS.
June 21-23. Annual meeting at Atlantic City, N. J. Secy., Edgar Marburg, University of Pennsylvania, Philadelphia, Pa.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
June 26. Annual convention at Thousand Islands, N. Y. Secy., Chas. Warren Hunt, 220 West 57th St., New York, N. Y.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.
June 29 to July 4. Annual meeting at Ithaca, N. Y. Secy., M. S. Ketchum, University of Colorado, Boulder, Colo.

AMERICAN WATER-WORKS ASSOCIATION.
July 10 to 14, inclusive. Annual meeting at Boston, Mass. Secy., J. M. Diven, 14 George St., Charleston, S. C.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.
July 19 to 20. Semi-annual meeting at Chicago, Ill. Secy., W. M. Mackay, P. O. Box 1818, New York City.

AMERICAN INSTITUTE OF MINING ENGINEERS.
July 23 to Aug. 4. Joint meeting with the Iron and Steel Institute at London. Secy., R. W. Raymond, New York City.

DETROIT ENGINEERING SOCIETY.—The regular meeting of the society was held May 25, when Mr. F. R. Still read a paper on "Small Vertical High Speed Self-Oiling Engines." In the afternoon a visit was made to the plant of the American Blower Co., by invitation of the company, after which the company gave a "Beefsteak" supper at the Fellowcraft Club. This movement was initiated by the American Blower Co. with the idea that it would be followed by other manufacturers, thus giving the engineers of the city the benefit of visits to the various manufacturing plants.

AMERICAN WATER-WORKS ASSOCIATION.—The twenty-sixth annual convention of the association will be held at Boston, Mass., July 10 to 14. Some twenty odd papers have been prepared for the convention, and are as follows: "A Symposium on the Chicago Drainage Canal Case," Dr. W. P. Mason; "Self Purification of the Mississippi River During the Later Part of Its Course," Mr. Robert Spurr Weston; "Sewage Disposal Works in Their Relation to Water Supply," Mr. M. N. Baker; "Stream Pollution," Mr. M. O. Leighton; "The Greatest Typhoid Fever Epidemic," Dr. Geo. A. Soper; "Extensions and Improvements in the Supply Main, Yarmouth, N. S.," Mr. Geo. H. Robertson; "Copper Sulphate Results," Prof. James M. Caird; "A Pictorial Appeal, Water-Works, Too," Mr. H. F. Dunham; "Water Softening for Municipal Supplies," Mr. Geo. W. Fuller; "The Growth of the Pumping Station," Mr. Chas. A. Hague; "Disinfection as a Means of Water Purification," Mr. Geo. C. Whipple; "Necessity of Sealing Meter Connections," Mr. F. C. Kingsbury; "Expanding Water Supply System," Mr. J. T. Fanning; "Notes on Comparative Efficiency of Cast-Iron and Riveted Pipe," Mr. J. L. Le Conte; "The Lancaster Filter Plant," Mr. P. A. Maignen; "Coal Burning," Prof. C. H. Hurd; "A Retrospect of an Arbitration on the Value of a Water-Works," Mr. Albert H. Wehr; "Pump Slipage," Mr. Albe L. Holmes; "The Simplex Water Meters," Mr. J. W. Ledoux; "Lake Cheesman Dam," Mr. Geo. T. Prince; "Description of the Metropolitan Water-Works," Mr. Dexter Bracket, besides papers by Profs. Gardner S. Williams, H. L. Russell, E. O. Jordan, Adolph Gehrman and Mr. John W. Hill. Headquarters of the convention will be at Rogers Building, Massachusetts Institute of Technology.